Executive Summary

In December 1996 the Superintendent directed the Deputy for Information Technology Services to lead a committee of five faculty and staff to investigate teaching and learning technologies. The committee charter consisted of seven tasks which compared other universities' use of information technology to the Naval Academy's.

Computer based information technology makes a significant contribution to teaching and learning. This was evident from studies conducted throughout the educational community. Although hardware, software, and networking technologies across campuses are diverse, the most common technology is the microcomputer. The most economical technology providing the greatest return on investment is courseware (software configured for academics). Although there is debate on how the technology should be used to teach and learn, there is agreement that a flexible and scalable data networking and electronic classroom infrastructure is essential. Distance learning as a teaching method is having a major impact in delivering education to off campus students. In addition to being functional it has proven to be profitable. Due to rapid improvements in IT, delivery vehicles include satellites, dedicated high speed land lines, and the world wide web. Distance learning settings can be as formal as a structured classroom or as informal as desktop microcomputer in an office setting.

Universities nationwide recognize that traditional education is being challenged by rapid advances in the development and use of information technologies. Available legacy, migration, and prototype technologies include computers, printers, scanners, projectors, electronic white board variants, and software. There is a preponderance of dedicated software for office suites, graphics and visualization, statistics and mathematics, engineering, English, history, social sciences, hard sciences including medicine and physiology, fine arts, world wide web, reference resources, productivity tools, CASE tools and compilers, and special purpose products to support such functions as communications and conferencing. Consequently universities are using these technologies to pilot developmental projects. They range from basic to exotic and include networking, electronic classrooms, curriculum applications, virtual reality, distance learning, mentoring and tutoring, exploring teaching and learning methods, program integration and administration, and professional training. Universities also recognize that complex integrated applications have short life cycles, steep learning curves, long development times; demand creativity and excellent vision; require an efficient business plan; and most importantly necessitate commitment by the institution to support the participating faculty.

As with other universities, the Naval Academy has developed its information technology environment to support a unique mission. It is very competitive in the development and use of legacy technologies. With the exception of distance learning and virtual reality, it shares the variety and complexity of projects found at different universities. Naval Academy concerns include an ambitious academic building renovation which offers an opportunity to embed information technology architecture to complement and support teaching methods; a student body whose education and future profession demand the use of sophisticated technology but are not provided formal core education or training in the subject; and a faculty who are struggling to develop and use technology with self-taught skills.

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I. Introduction

A. Tasks, Participants, and Process.

On 12 December 1996, the Superintendent directed the Deputy for Information Technology Services to establish a committee of faulty and staff to investigate information technologies available to teach and learn, and to recommend how these technologies can support the Naval Academy's Mission.

Committee members included Captain H.J. Halliday (Director of the Division of Mathematics and Science), LCDR Michael Greico (Division of Professional Development), Professor Rae Jean Goodman (Director of Teaching and Learning and the Chair of the Academic Dean's Gold Ribbon Committee), Professor Alan Adams (Mechanical Engineering Department), Associate Professor Wayne Pearson (Chemistry Department), and Associate Professor John Kolp (History Department).

The original charter, Appendix A, consisted of five tasks focusing on the use of teaching and learning technologies to support the academic mission of the Naval Academy. They included:

- Task 1. Define teaching and learning technologies. Identify available legacy, migration, and prototype technologies. Present profiles of projects at other institutions.
- Task 2. Describe the Naval Academy's complete technology environment. Present teaching and learning technology efforts ongoing at the Naval Academy, the Naval Academy Preparatory School (NAPS), and the Naval Station.
- Task 3. Identify teaching and learning technologies best suited for faculty and midshipmen use. Discuss how selected technologies can be used to teach and learn. Explain methods for developing, integrating, and implementing these technologies. Present resources available and obstacles to overcome. Include investment costs, return on investment, and recommended modifications to present environment.
- Task 4. Demonstrate teaching and learning technologies.
- Task 5. Offer final recommendations with a forecast of potential benefits.

Subsequent to the original charter, two tasks were added. They are included:

- Task 6. Discuss an entry level computer course for midshipmen.
- Task 7. Provide configuration advice to the Academic Dean to support the academic building renovation.

The seven tasks were divided into 14 sub-tasks and assigned to various members of the committee. Committee members were encouraged to contribute to tasks not formally assigned to them. A status report was submitted to the Superintendent on 27 March 1997. The committee met periodically February through mid May.

B. Definition of Computer Based Teaching and Learning Technologies.

A computer based teaching and learning technology is a delivery vehicle for data and/or information, used by an instructor to support and complement a method of instruction, in a formal or informal setting. Teaching and learning with computer based information technology requires carefully selected software and hardware tools, well developed and supported environments, and appropriate teaching methodologies. *Tools* are technologies such as computer systems, software applications, media bases, and data networks. A media base stores video, sound, and character based data whereas a database stores mostly alpha numeric character based data. *Environment* is the location where technology is used such as a classroom. *Methods* consist of lecturing, coaching, team teaching, cooperative learning, Internet based learning, interactive learning, and distance learning. The methods determine the technology required to teach and learn. While an elementary level of inexpensive standalone technology can add quality to the most traditional lecturing method, other methods such as distance learning require expensive integrated technology suites and can be technologically demanding. An example is lecturing (*method*) in a classroom (*environment*) using a microcomputer to drive a projection system which displays data and/or information from a software application accessible over the classroom network (*tools*).

C. Effect of Computer Based Information Technology on Education.

With the information age gaining momentum, technology's use is seriously challenging traditional teaching and learning methods. In many instances it is confusing and threatens the educator. Desktop computing, the availability of affordable technology in the classroom, the advanced development of many of the hardware and software technologies, and the reality of such applications as virtual reality are forcing institutions to rethink the 'business and methods of offering education'.

Several questions are being asked. One is 'Does technology significantly contribute to student learning?' Several studies to understand educational technology's effectiveness have been conducted emphasizing mode of instruction, media attributes, context of learning and distance learning success factors. Another question is 'How should technology be used to enhance teaching and learning?' There is general agreement that information technology has *potential* in education but there is little agreement on the best way to use it to enhance academic productivity. Appendix B is a treatment of both of these questions.

One area where technology has had an impact on education is delivering instruction to students separated by distance and time from the traditional classroom. This methodology of teaching students at remote sites is known as *distance learning*. The technology, *video teleconferencing*, is rapidly gaining in popularity and offered at many colleges and universities throughout the country. With video teleconferencing comes the necessity to understand not only the technology but the implications to both students and educators. Distance learners have special needs including advising, access to learning resources, geographic isolation from instructors and possibly other students, and academic administration. How these needs are addressed will affect student attitudes toward distance learning and how well they learn. Distance educators have special needs such as developing a new set of technical skills and instructional methods. Distance learning is discussed in Appendix C.

II. Findings

A. Technologies at Other Institutions.

1. Overview. In 1987 the Carnegie Foundation prepared the Carnegie Classification for Higher Education which cataloged 3,300 colleges and universities into 19 classifications. They have been further reduced to six groups which include Research Universities, Doctorate Granting Universities, Comprehensive Colleges and Universities, Liberal Arts Colleges, Two Year Colleges and Institutes, and Professional Schools. The categories are based on financial support, degrees and disciplines offered, research priority, and enrollment. In many cases the category of institution determined the creativity, aggressiveness, pursuit, and use of technology as an integral part of the institution’s teaching and learning mission. This was acceptable during the early days of desktop computing, networking, and projection technology. However, today we are in the middle of an information revolution where technology is essential for success and provides a competitive edge in education. Consequently schools in all categories are spending tens of millions of dollars annually to develop information technology applications in an effort to attract the bright students and productive faculty .

The microcomputer is the most common technology on college campuses. It did not become a productive tool until the early to mid 1980's. The typical configuration was 256K of random access memory (RAM), one or two 5 1/4" floppy disk drives (FDD), no hard drive (HD), and a low resolution color graphics adapter (CGA) monitor, costing $4,000-$5,000. Software was limited to the users ability to develop an application. Third generation languages such as Formula Translation (FORTRAN), Beginners All Purpose Symbolic Instruction Code (BASIC), and Pascal were popular. Fourth generation languages such as dBase were in their infancy stages. Life cycles were predicted to be five to eight years. These machines are museum pieces today with no market value. In 1990-1991 the 80386 became the interim (migration) machine soon to be replaced by the 80486 in 1992-1993. With improved hardware technologies, software manufacturers developed 4^{th} and 5^{th} generation languages and so began the chicken and egg duel, between hardware and software manufacturers, which we are experiencing today. Life cycles shortened to two years for hardware and 18 months for software. For the sake of this report computing begins in 1992. During these initial legacy years desktop microcomputers were not capable enough to support requirements of most engineering schools. Although workstations such as the SUN Sparc 1 and SUN Sparc 2 became popular among the engineers and scientists for their graphics and speed minicomputers and mainframes remained the institutional computers of choice on most campuses. In addition to providing for administrative requirements they also supported computer aided instruction (CAI). It was not uncommon for the larger mainframes to provide computational work (back end) to support engineering applications written in FORTRAN, with workstations such as Tectronics, Evans & Sutherland, and SUN providing the visualization (front end) in the classroom and laboratories. The most popular legacy systems were International Business Machines (IBM) and Digital Equipment Corporation (DEC) variants running operating systems such as VMS and Unix. Campuses had limited connectivity. Legacy networks were coax, copper, and some pre-standard fiber. In most cases they were configured with 200 - 500 nodes. Today campus networks are standard fiber configured for multiple topologies with thousands of nodes.

2. Available legacy, migration, and prototype technologies. A *legacy technology* is one which is currently in use, and has been well established for a given period of time. An example of a legacy technology at the Naval Academy is the Honeywell-NATS system, in use for 26 years. A *migration technology* is an interim solution, replacing the legacy technology, while waiting for the implementation of the new, final, technical solution. When the requirement to replace the legacy system is time sensitive and mission critical, a migration solution is installed to provide time to research and develop the final solution. When legacy systems are complex, embedded, and fully integrated; it is a difficult, lengthy, and costly process to migrate. In most cases, once the migration solution is in place, a *prototype* of the final solution is established to learn about the technology. Prototypes also ensure the selection of a supportable, affordable, maintainable, and functionally appropriate technology. Many institutions never decide on a final solution. They are finding that with very short product life cycles and increasing user demands, migration becomes a continuous process. Continuous migration and lack of life cycling presents an investment dilemma in technology as a critical issue. Consequently, depending on availability of institutional resources, what may be a legacy technology at one institution is being prototyped as a migration technology at another institution. The following are typical technologies one might find available at different colleges and universities today:

a. Computer technology. Computers include the desktop microcomputer, the desktop workstation, the minicomputer, and the mainframe.

(1) Microcomputer. Although there are some schools with major investments in Apple products, most universities use Intel (or AMD and Cyrix) based desktop microcomputers,, as their principal computing device. Various reasons include the availability, variety, and cost of software; openness of the architecture; and cost of maintenance. Three of the most important variables in microcomputer technology are speed (central processor unit(CPU) and video), memory, and expandablity. As recently as 1994 there were approximately 500 assemblers of Intel 80486 microcomputers in the continental United States. It is therefore no surprise that legacy 80486 technology is common at many larger universities but quickly being replaced with high speed Pentiums, configured for scalable networks, with lots of memory, and full motion multimedia. Typical entry level 80486 systems had speeds from 25 MHz to 33 MHz and 4 MB to 8 MB of random access memory (RAM). Today a new Pentium based microcomputer can be purchased with speeds up to 233 MHz and RAM in excess of 60 MB. These machines outperform many of the workstations offered in the early 1990s. Most microcomputers run one of four operating systems: Disk Operating System (DOS), DOS-and-Windows, Windows 95, or Windows New Technologies (NT). Since the operating system provides the instruction set for the computer to operate, they (operating systems) all have different requirements and don’t all support the same application software. DOS-and-Windows is most common among the legacy systems while Windows 95 is most common among newer systems. Although most microcomputers are general single user systems, they can be configured as a network file server or print server.

(2) Workstation. The workstation is a more capable system. In many cases it looks like a desktop microcomputer. There are four categories of workstations. They include the component design workstation, the system design workstation, the facility design workstation,

and the functional workstation. Popular workstations found at most universities include the SUN Microsystems (SUN), Hewlet Packard (HP), Digital Equipment Corporation (DEC), and Silicon Graphics Incorporated (SGI). The SUN is most popular because of its flexibility. Although there are various Intel based (Pentium central processors) workstations, most run a Unix variant operating system. Unix is the operating system of choice for most research professionals. In addition to running Unix, workstations are multi-user systems, allow multi-tasking and multi-processing, run a wealth of public domain software, are superior development machines, and can run with several different configurations allowing the machine to become one of several different types of server (departmental, print, mass storage, etc). Workstation technology is an excellent choice for high resolution graphics, computational intensive mathematics, 3D visualization, design, virtual reality, artificial intelligence, and departmental network servers. The SUN Sparc workstations with reduced instruction set (RISC) architecture are the most common legacy systems for component and system design work. SUN Sparc and SGI share the legacy market for graphics and functional work. Although microcomputers are challenging the workstation market, workstations still offer superior architecture.

(3) Minicomputer. A minicomputer, in many cases, is a physically larger and more capable computer system with special design features which allow it to support many users simultaneously. A difference between the workstation and the minicomputer is in the architecture (64 bit) and speed (300 mhz) of the machine. Minicomputers also provide focused functionality, but more importantly are excellent choices as institutional or enterprise servers. In the recent past, clusters of minicomputers have been replacing single point of failure mainframe computers. Once again the SUN offers a popular line of minicomputers. The SUN Sparc Server 1000, 1000E, and 2000 are very popular. The newer line of SUN minicomputers include the SUN Ultra Enterprise Servers. In particular is the Ultra 3000 and the Ultra 4000. They are excellent client-server machines and database machines, scalable with the capability of running several CPUs, have lots of memory (gigabytes) and offer safe redundancy.

(4) Mainframe. Mainframe computers are rare. They are very large, expensive, and support a central computing paradigm instead of a distributed computing paradigm. Today institutions, including the Naval Academy, emphasize distributed computing as much as possible placing the production and computing capability in the hands of the user. IBM still emphasizes its mainframe line of computers, although the SUN Ultra 10000 is becoming a serious competitor.

b. Printer Technology. Universities are rapidly moving away from dot matrix technology in favor of the Laser and Ink Jet technologies. They provide quality and speed, offer color, and use regular sheet fed paper. Laser printers are gaining in popularity as networked production printers with a single printer being capable of serving an entire department. In addition to quality, printer capability can best be described by the number of dots per inch (dpi), speed in pages per minute (ppm), and memory (MB). A typical legacy HP LaserJet 4+ has 600x600 dpi, 12 ppm, and 2 mb memory. Color printers are similar. The popular legacy HP DeskJet 1200C offers 600x300 dpi, 7 ppm, and 2 MB memory. Network printers such as the HP LaserJet 4SiMX offers 600x600 dpi, 17 ppm, 10 MB memory, and Ethernet (for networking).

c. Scanner Technology. This technology has the appearance of a copy machine. The 2 dimensional objects [paper] are scanned to a digital file. Scanners are color capable and come with high resolution and text recognition software and automatic scanning image software which enhances documents with high quality images. Again dots per inch and recognition capability are important variables. The HP ScanJet Iic/IIcx have autofeeder capability, 400 dpi, and 24 bit recognition. There are also smaller hand held scanners. An example is ViewScan by Ultima International Corporation.

d. Projection Technology. Projection technology consists of hardware devices capable of projecting simple overhead projection slides, complex three dimensional objects, or any computer image which is displayed on a monitor. It allows an instructor to run a discipline specific software application and project any aspect of the application (i.e. computation or graphic) for the entire class to view. It has become a popular supplement to traditional classroom lectures. Some are simple and feature one or two functions while others are fully integrated offering many more functions including remote control, sound, and motion including VCR input. Typical costs for a single standalone system vary between $2,000 and $10,000. The various categories of projection technology include the following:

(1) Simple liquid crystal display (LCD) panels fitting on top high intensity overhead projectors can be found at literally every institution. The latest models are very sophisticated, display high resolution full motion video, integrate sound, and are remotely controlled. Typical products include the Rainbow 30 LCD Projection Panel by Chisholm and the MagniView 498 by Dukane Corp.

(2) Other equipment can also project three dimensional objects. These systems stand upright approximately 14 inches, have a very small foot print, auto focus and magnification features. The newer models have a detachable high resolution camera head. Typical products include the AV-P700 Video Presenter by JVC and the DT 100AF by ELMO Mfg.

(3) The most popular, most numerous, and most expensive is the completely self-contained video presentation system. It can be driven by a PC, VCR, laser disc, or digital camera. It has audio support and a wireless remote. Most are the size of an old fashion slide projector. The more popular products include the APS 1000 by Panasonic, the Video Flex by Ken-A-Vision, the CPL550 by Hitachi, the Aurora S500 and Nova V375 both by Chisholm, the Image Pro by Dukane Corp, the Polaview by Polaroid, the Synergy by Apollo, the Ovation+ by Proxima, the Note-Vision by Sharp Electronics, and the TeleCamera by Howard Enterprises.

e. Board Technology. Classroom chalkboards and dry erase whiteboards are being supplemented with electronic whiteboards and Smart boards. The electronic whiteboard comes in different sizes from portable to permanently mounted. Using the traditional chalkboard paradigm, the instructor writes and erases on the board as he/she normally would. The hand generated drawings, graphs, notes, etc. can be captured electronically and printed real-time for distribution to the class. The Smart board is an interactive electronic whiteboard. It requires a microcomputer and LCD projector. Once projected on the board, the image is touch sensitive and can be manipulated at the board by the instructor.

f. Software Technology. The widest range of technology exists in software. Software can be maintenance intensive, has steep learning curves, and can be costly to tailor and develop. Software is also a critical variable in defining hardware requirements. Advances in hardware technology such as architecture, memory, and speed allow software to perform functions once reserved for hardware solutions. Software offers functionality not possible as recently as a few years ago. Consequently, most differences in technology from campus to campus will exist in their software. Software consists of operating systems, drivers, accessories, generations of language compilers and assemblers, computer aided software engineering (CASE) tools, and a variety of applications. Complex commercially available software packages and software suites are applications and adaptations of integrated higher order languages. While some software is fun to use and simple to understand other software is very complicated, will only run on expensive hardware, and demands patience and advanced training to understand. Software applications exist for literally every discipline and in some cases provide an excellent substitute for reality. While it is impossible to list all software technology used at other institutions, the following applications are what one might see from campus to campus depending on the type of institution:

(1) Office Software provides a suite of software tools for a typical administrative office environment including word processing, publication, spread sheets, graphics, and presentations. Two of the most complete office software packages are Microsoft Office and Corel Perfect Office. Each of the tools in the office suite can be purchased separately. In the past many institutions allowed their faculty and staff to assemble and tailor their own office environments. Today it is easier and much less expensive to purchase the entire suite.

(2) Graphics and visualization software provides tools to manipulate, display, query, statistically analyze, visualize, interpret, and understand data. This technology also facilitates technical graphing and 3 dimensional modeling. Real multidimensional visualization with volumetric rendering and slicing supplements simulation and adds another dimension to teaching, learning, and research. Some of the products available include ArcView GIS by ESRI, KaleidaGraph by Synergy Software, SCULPT by Interactive Simulations, SigmaPlot by SPSS Inc., Tecplot by Amtec Engineering Inc., and Slicer by Fortner Research.

(3) Statistics software offers a wide variety of features including extensive multimedia capability excellent for integrating multiple sources of data, literal generation of statistics from raw data, graphics, and extensive analysis including exploratory analysis, correlation, cluster analysis, reliability, predictive modeling, and forecasting. Examples of products include ActivStats by Data Description Inc., JMP by SAS Institute Inc., MINITAB by MINITAB Inc., StatView by Abacus Concepts Inc., and SYSTAT by SPSS Inc.

(4) Mathematics software offers the same variety as does statistics software. There are interactive instructional and assessment software for college level math courses; application software for algebra, calculus, trigonometry, matrix theory; mathematical problem solving software; and data analysis and graphical modeling. Typical products include Derive by Soft Warehouse, LabVIEW by National Instruments, Maple by Waterloo Maple Inc., Macsyma by Macsyma Inc., MATLAB by Math Works Inc., and Mathematica by Wolfram Research Inc.

(5) Engineering software consists of design software, simulation software, and modeling software. It is excellent for lab environments. Most products are bundled into suites offering a wide variety of functions for serious engineering faculty and students. This software offers applications which provide: two and three dimensional drafting and modeling, architecture, interior design, building details, facilities, accessories, facades, aerial views, perspectives and complete computer aided design (CAD); complete simulations for electrical and electronic laboratories including complex instrumentation; and use of animation, graphics, and audio. Typical products include Architectural Design and Engineering Academic Suite by Bentley Systems, Autodesk Collection by Addison Wesley Longmen, CircuitMaker by MicroCode Engineering Inc., DenebaCAD by Deneba Software, Design-Expert by Design Expert 5, Electronics Laboratory Simulator by Falcon Software Inc., LogicWorks Modeler by Addison Wesley Longmen, Multimedia Engineering Dynamics by Addison Wesley Interactive, PDEase2D by Macsyma Inc., and TraxMaker by MicroCode Engineering Inc.

(6) English software offers three types of products. One is an author's complete set of literature with commentary, historical facts, and illustrations. The second emphasizes teaching and learning to write and communicate. The third teaches how to speak English, especially useful for English as a second language application. A sample of products include Chaucer Life and Times by Primary Source Media, 19th Century American Literature by Que Inc., Daedalus Integrated Writing Environment by The Daedalus Group, Techwrite by Logicus Inc., and Dynamic English by DynEd International Inc.

(7) History software consists of products on subjects ranging from art to empires. In addition to historical narrative, this software includes audio and video links, known history Web sites, maps, and high resolution images. Examples of this software include The Art Historian by The Reindeer Company, World History Interactive Library by Thynx, Splendors of Imperial China by The Metropolitan Museum of Art, and The Asian American Experience by Primary Source Media.

(8) Social science software mentioned below is for psychology. The software investigates psychology concepts using motion, sound, and virtual laboratories. Subjects sensation, perception, classical conditioning, etc. Software products include Exploring Perception by Brooks/Cole, Multipsych by Life Science Associates, and The Integrator: Intro to Psychology by Brooks/Cole.

(9) Sciences, medicine, and physiology software is available in a multimedia format emphasizing discipline concepts, 3 dimensional visualization, and complete analysis. Examples of this software available include Interactive Plate Tectonics by McGraw Hill Higher Education Group, Interactive Anatomy by A.D.A.M., Iteractive MedWorks Anatomy & Physiology by Victory Technologies Inc., Metazoa by Metazoa Software, and Inorganic Chemistry by Snowbird Software Inc.

(10) Two Fine Arts software products include Experiencing Music Technology by Schirmer Books, and Practica Musica by Ars Nova. Experiencing Music Technology is a combination textbook and CD-ROM which begins with basic music notation and has 21 projects

for students to complete. Practica Musica provides electronic tutoring, explores rhythm tapping, chord progressions, etc.

(11) World Wide Web (WWW) is growing exponentially. The Web offers inexpensive opportunities to improve the quality of administrative, teaching, learning, and research experiences. Software is available to bridge the gap between those who want to develop Web applications but don't understand HTML or Java. Web software creates new documents and imports legacy documents onto an existing Web site. This software also provides management and analysis for complicated and heavily used Web sites. Examples of Web software include TemplateMASTER by Erica Sadan, Web Publisher by askSam Systems, IntraBuilder by Borland International, network MCI WebMaker by MCI Inc., Statisphere by O'Reilly & Associates, and ToolBook Librarian by Asymetrix Corp.

(12) Reference resource software consists predominantly of generalized resources such as dictionaries, thesaurus', and encyclopedias. This software has been in the marketplace for several years and in many cases comes bundled as a part of various office suites. More and more references are being produced as networked on-line products. Automated libraries are an excellent source of these products. An example of a good reference resource is the World Book Multimedia Encyclopedia by IBM Inc.

(13) Productivity software consists of suites of tools for managing bibliographies, classrooms, and general information technology including electronic mail (e-mail). Bibliographic management tools improve effectiveness and efficiency in organizing, conducting, and documenting literature searches from bibliographic references. Examples of these products include Bookends Web by Westing Software, BookWhere Pro by Research Information Systems, ProCite by Research Information Systems, EndNote Plus by Niles & Associates Inc., and TakeNote! By Academic Software Inc. Classroom tools assist in planning, scheduling, and developing lessons and curriculum in addition to analyzing individual or group grades and generating various reports. Examples of these products are Daily Plan-it by SmartStuff Software and Grade Manager by TeacherWare. Information technology management tools assist in handling e-mail attachments and downloaded files from the Internet; perform file backup, file compression search and retrieval; and provide general planning and scheduling for anything from classes to appointments with built in audio alarms. Although some of this is included in certain office suites individual products can by purchased. Examples of such products include E-ttachment Opener by DataViz Inc., MailArchiver by Blue World Communications Inc., ACT! By Symantec Corp., ASCEND by Franklin Quest Company, and IdealDesk by Interlinear Technology Inc.

(14) CASE Tools and Compilers. We have included CASE tools and compilers for completeness. CASE tools are computer aided software engineering tools. A CASE tool helps author and build a software product. Many of the products and software technologies listed above were created with the help of CASE tools. There are hundreds of CASE tools for literally every aspect of computer technology too numerous to profile in this report. They are very complicated and in most cases very expensive. In 1992 there were in excess of 400 CASE tool products. Compilers are software which translate programs written in third generation computer

languages such as FORTRAN, BASIC, Pascal, Ada, into machine language. Each language has a dedicated compiler. In many instances products once developed by compilers are now developed by higher order languages and CASE tools.

(15) Other special purpose software exists such as communications software, WWW conferencing software, authoring software, and integrated toolkits for specific applications.

g. Data Communications Technology. Data communications, commonly known as networking, requires a data path such as fiber or copper cable, various protocols which establish ‘data rules’ for traveling on the network such as ethernet, a network operating system such Novell’s Netware, and a computer as the server which hosts the protocols, network operating system, and user applications. Networks are the glue that ties all technologies together. Most campus networks have at least one traditional network server which provides mail and messaging, sharing data files, and software applications. Networks are referred to by the manufacturer’s name such as Novell and Banyan, product names such as Appletalk (Apple) and NT(Microsoft), or by the network operating system’s name such as Netware (Novell).

h. Interactive Education and Training Technology. This is a tailored data communications technology which offers specific functionality to the instructor in an electronic classroom such as video control of student computers. The instructor will be able to scan through the entire class and display his/her computer solution, or an individual’s, to another individual or to the entire class. It also allows the instructor to control a student’s mouse and keyboard or to freeze student keyboards and darken their monitors to capture their attention. Two examples are CLASSNET by Minicom and V-Net by Inline Inc.

i. Video Teleconferencing Technology. Video teleconferencing technology is the technology required for the distance learning methodology. It allows an instructor to deliver a real time presentation, including motion and sound, using all of the training aids normally required of the class being taught, to numerous remote sites simultaneously. Students from the remote sites can interact with the instructor real time as if they were sitting in his/her classroom. The delivery vehicle is either satellite or land line. Land line is T-1 or ISDN. There are several variations of this technology including a formal classroom specifically architected and constructed to support teleconferencing, to the individualized desktop video teleconferencing from the Internet. Like many of the newer technologies this requires an integrated suite of hardware and software technologies designed to deliver full motion multimedia (video and sound) to the desktop. Some products which support this include Being There 3.0 by Intelligence at Large Inc., CU-SeeMe by White Pine Software Inc., SMART 2000 Conferencing by SMART Technologies Inc., and Teaching Pro 5000 by NEC America Inc.

3. Profiles of projects at other institutions. Most colleges and universities recognized that traditional education is repeatedly challenged by continuous advances in digital information technology (IT). They also recognize complex integrated IT has short life cycles, steep learning curves, long development times, requires creativity and vision, demands an excellent business plan, requires specialized skills, and will be costly. Consequently, it is not surprising that almost all institutions are piloting projects to develop new ways to teach and learn using information technology. Most developmental projects fit into one of the following categories: networking, electronic classrooms, curriculum applications, virtual (reality) applications, distance learning, mentoring and tutoring, exploring teaching and learning methods, program integration and administration, and professional training. In the early to mid 1990's most institutions concentrated on developing campus networking and classroom automation. Today distance learning and virtual applications dominate academic teaching and learning projects nationwide. Success in developing and using IT to create efficiencies and to improve teaching and learning requires institutional commitment, new faculty skill sets, and large investments of time. The following profiles illustrate the variety and complexity of developmental projects at other institutions:

a. Networking.

(1) Ball State University: Teaching and Learning using a networked Video Information System**.** The point of contact is Frank Sabatine, Coordinator Business and Technology Development (telephone 317-285-8304). The project included installing fiber connectivity to all buildings on campus including dorms. The campus library became the central repository for all academic material. Wide area connectivity connected the campus network to the Internet. Every faculty member can have material sent electronically from the library to an office or classroom. Every classroom is equipped with at least a monitor. Thirteen classrooms have multiscan projectors and real time access to all library material. Integrated classroom equipment includes Mac, PC, VCR, laserdisc player, and an ELMO projector. This project includes a full service media facility called Teleplex. equipped with video production equipment to provide animation, graphics, and presentation materials for a distance learning program and individual faculty. Distance education is provided via satellite and the Internet. Each semester short courses offered to all faculty on use of computer, creating courses for Web, and creating professional class presentations. Currently the school is extending distance learning world wide, negotiating with company in Germany to deliver the MBA program live via satellite to Malaysia, Vietnam, and South Africa.

(2) University of Oregon: Networked Courseware. The point of contact is Greg Bothum, Professor of Physics (e-mail: nuts@moo2.oregon.edu). This long range project develops a campus network into an effective teaching tool. It won the Cause Award for Excellence in Campus Networking. The project was driven by the "do more with less paradigm". It emphasized technology based education, especially network based instruction using the WWW, to increase faculty productivity by accommodating more students with existing faculty. Networked course material was created and presented by the faculty and access by students over the campus network. The project was conducted as an experiment where failure is an acceptable conclusion. To date the advantages include the ability to acquire data real time and use it in the classroom; the ease of developing and customizing a curriculum; the convenience of organizing, preparing, and presenting lectures; and use of courseware to better engages the motivated student. The disadvantages include alienation of ~15-20% who resent having to use computers and paying for campus infrastructure needs. The project emphasized that animation, simulation, graphics, and visualization increased quality of learning. Although students learn best when

engaged in visualization, this technology a major investment in time, funding, and talent. The most serious drawback was that instructor preparation time and skills development was not recognized by the institution, especially for promotion and tenure credit.

(3) Boston College: Project Agora...Consolidated Student Communication System. The point of contact is David McCormack, Assistant Director Management Information Systems (e-mail: david.mccormack@bc.edu). The project integrated voice, data, cable TV communications throughout the campus including dormitory rooms to create electronic communication environment. It provided students and faculty opportunities to conduct academic and social business using any communications medium at any time. The project won the CAUSE award for Best Practices in Applications Award.

(4) Duke University: Infrared Networking in the Classroom**.** The point of contact is George Stetten , Director of Duke's Visualization and Image Analysis Laboratory (telephone 919-660-5363). This is a School of Engineering project. The project changed the teaching methodology in the Numerical Methods and Programming class. It emphasized using notebook/laptop computers. At beginning of the semester each student receives a COOPERATIVE transceiver(wireless), by Photonics Inc., which plugs into the printer port. Screen sharing is accomplished with Farallon Computing's Timbuktu software. The network is peer to peer. The instructor can view any or all students' notebook monitors and take control of keyboards at any time. Instructor can provide individual help to to any student. The network can physically exist anywhere at anytime.

b. Electronic Classrooms

(1) University of Toronto: Multimedia Classroom. The point of contact is Michael Edmunds, Director of Information Commons (telephone 416- 978- 6510). The project consists of building 20 electronic classrooms across campus. Five rooms remain to be built during the summer of 1997. The rooms were architected from ground up. The controls run off an 80486 microcomputer. Adcom Electronics iRoom software is used. The wall size screen has touch screen functionality and is icon driven. Applications used in the classroom include virtual reality and animation technologies. GRAFIK Eye software by Lutron is used for setting screens & lighting. These rooms have been built in Humanities, Chemistry, Mechanical Engineering, Chemical Engineering, Mathematics, and Physics. All rooms have data projectors connected to campus network.

(2) Northwestern University: Advanced Smart Classrooms. This project consists of large multimedia lecture halls equipped with ceiling projectors, sound systems, application computers, VCRs, laserdisc players, slide projectors, overhead visualizers, and software. The classrooms are networked (Ethernet). Presentation software includes Persuasion Player, Power Point, Acrobat Reader, and Compel. Network Communication Software includes Netscape, Telnet, NewsWatcher, Fetch, TurboGopher, Archie, Ph, MacSlip, Eudora, NUPOP, PC Slip. System Software includes DOS/Windows, System 7.5, QuickTime. Other application software consists of MS Word, Excel, and Toolbook. Those students and faculty who desire to use the

classrooms can gain on line information for, scheduling a room, classroom support for technical problems, user training, equipment & software.

(3) Canisius: Instructional Technology Classrooms (ITC).This project includes the development of instructional classrooms with integrated computer and audiovisual equipment to assist faculty in teaching. The rooms are divided into four levels, the basic classroom to the advanced full teaching classroom. A level 1 ITC has a VCR, TV Monitor, and Laserdisc player. A level 2 ITC has centrally located microcomputer, cd-rom, video projector, and wall mounted screen. A level 3 ITC has student workstations networked to instructor. A level 4 ITC similar to level 3 but with more advanced workstations.

(4) California State University: Multimedia Classrooms. This project developed three categories of classrooms equipped to teach with multimedia. The physical classrooms already existed. The project dealt with deciding on classroom functionality and selecting appropriate equipment. The Masters Classroom was equipped with overhead transparency projectors, VHS VCR, campus TV cable broadcast equipment, visual presentation projectors, computer display projectors, campus network access, wide area Internet access, and off campus phone line. The Presentation Classrooms had limited projection capability. The Broadcast Classrooms has broadcast TV capability only.

c. Curriculum applications (Multimedia, Intranet, and Internet)

(1) Chatham College (Pittsburgh): Student Writing Assignments On-line. The point of contact is Anne Steele, VP Student Affairs (telephone 412-365-1157). This project developed a system for students to electronically file writing assignments on-line, and to have professors grade them on-line with imbedded voice annotations. It was experimental (proof of concept). It required an improved dynamic networking capability. The students and professors used MS Word and MS Mail. The e-mail can be text based or audio based. Using MS revision tools, faculty edit the student’s work while maintaining original text.

(2) The Pennsylvania State University (Penn State): Multimedia Curriculum. The point of contact is Peter Bennett, Associate Dean (e-mail: pdb1@psu.edu). This project was developed by the Smeal College of Business for a new undergraduate curriculum called Curriculum for Undergraduate Business (CUBE). The project integrated selected areas of business school study with multimedia and 3D interactive technology. The course is lab intensive and emphasizes the use of digital video, audio, and graphics.

(3) Florida State University: Multimedia Through the Internet. The point of contact is Bruce Meintjies , Florida State University College of Arts and Sciences (telephone 904-644-5264). This project uses LCD Multimedia Projection Technology. Faculty are instructed on how to use the Web (WWW...Internet) and various hardware and software technologies to develop course material. Following the instruction they develop tailored courseware. The classroom projection equipment consists of microcomputer driven Sharp XG E1100U multimedia projectors located throughout the University. This projection equipment was selected because it can be used with the classroom lights on. Previous attempts to use less powerful

projection systems required interior classroom lighting to be off. This prevented students from taking notes and inhibited learning.

(4) Northwestern University: Development of Multimedia Resource Data Bases. Points of contact are located at the Institute for Learning Sciences at (telephone 708-491-3799. This three year project was developed by Northwestern's Institute for the Learning Sciences. Northwestern teamed with Arthur Andersen, Ameritech, and North West Water PLC on this three year project which started in 1995. Each participant contributed $1.5 million annually. One hundred and sixty programmers, graphic artists, psychologists, and academics developed a wide variety of software tools and multimedia databases. They created case based learning templates, stored real world corporate memory, and developed training applications. Examples of their products include 'ASK', a system of video databases that answers commonly asked questions in any field; 'MO-PED' which stores training applications for service oriented occupations; and 'GuSS' (Guided Social Simulation) which consist of simulations of complex social situations.

(5) University South Dakota: The House the West Built. The point of contact is Professor Clayton Miles. The project consisted of developing the institution's Western Civilization course on-line accessible using the URL http://www.usd.edu/honors/hwb.html). The project started with teams of 5 people, including students, who researched an aspect of Western Civilization and presented their results on the WWW. They used a combination of graphics, audio, and video. This is an excellent project and adds some variety to an otherwise common course.

(6) Wake Forest University: The Template, a New Tool for Collaboration on Campus. The point of contact is David G. Brown, Economics Professor (e-mail: brownd@wfu.edu). This project uses the IBM ThinkPad Notebook Computer, provided to all incoming students, as the hardware technology for this project. The software consists of a custom designed Notes-based course and project filing system called the Wake Forest Template. The Template "enables an electronic file cabinet for every course, every student organization, and every campus committee". Classrooms used are networked. The essence of the project is to have students collaborate on all work assigned. Collaboration occurs in and out of the classroom with e-mailed attachments as the principle vehicle for communications. Everything submitted by the students and responded to by the professor is done on-line with as much real time feedback as possible. Courses taught using the Template are virtually paperless. The professors are of the opinion that this encourages and helps improve the learning process.

(7) Northwestern University: Web Site Multimedia Database and RealAudio of Supreme Court. The point of contact is Jerry Goldman Political Professor at (telephone 847-491-2637 or e-mail: j-goldman@nwu.edu). The project URL is http://oyez.at.nwu.edu/oyez.html. Professor Goldman's goal is to complete the project in 1998. The project examines the United States Supreme Court politically, historically, and culturally. To date there are 750 hours of original unedited oral arguments in supreme court with 70 court cases completed. The project includes biographies, pictures of the justices, text of oral arguments, and approximately 1,000 links to court cases. The national archives for the raw data is in Maryland.

(8) University of California at San Diego: Space Program Research Project. This project is being conducted jointly with Caltech, Standford, Harvey Mudd, and Johns Hopkins University. The point of contact is JoBea Way, (e-mail: way@lor.jpl.nasa.gov). The project, sponsored by NASA, provides students with an opportunity to participate in different aspects of the United States space program. Students are linked to the space shuttle missions and receive images from space realtime over the Internet. They participated in designing and building a mission control gateway through which they maintain communications with NASA's Mission Control Center in Houston. They track shuttle journeys using 'Satellite Tool Kit' software from Analytical Graphics Inc. This software used by the space industry to analyze complex relationships involving satellites, orbits, launch vehicles, ground stations, and targets. They also write flight software as part of flight team at Caltech's Jet Propulsion Laboratory (JPL). One goal of the project is to use software to conduct 'fly-bys' whereby students from one school can fly by another school to deliver flight data. This will be done with the help of the Caltech's Digital Animation Lab.

d. Virtual applications, simulations, and robotics.

(1) Columbia University: Simulated Trading Room. The point of contact is John Ellrodt, Assistant Director of Instructional Technology (telephone 212-854-6091 or e-mail: je@columbia.edu). The project allows students to simulate an actual stock market trading room. The data feed is Dow Jones Telrate. It is fed into Excel for analysis of market data. EXPO software allows students to execute an actual trade. EXPO is a real time graphical analysis tool. Funding for this project is a grant from Leading Market Technologies.

(2) West Chester State University: Virtual Biology Laboratory. The points of contact are Professors John T. Beneski and Jack Waber, Department of Biology. Their Web site locator is http:/www.wcupa.edu. This project presents an alternative to the traditional biology laboratory. It is designed to improve effectiveness and efficiency of biology laboratories. It is CD-ROM based and interactive. Topics range from cell chemistry to ecology. As an example the project uses Bodyworks 4.0 for human dissection. It completely replaces the lab. Students actually perform experiments, gather data, analyze data, and interpret data. In the process they are exposed to microscopes, radioscope counting, electrophoresis, chromatography, etc.

(3) Virginia Commonwealth University and Medical College of Virginia: CD-ROM Based Instructional Program for 1st Year Medical Students. The point of contact is Carol Hampton, Assistant Dean for faculty and Instructional Development at the School of Medicine. The project supports a lab course which covers gross and sectional anatomy (central nervous system of head neck, scapular and deltoid regions) and basic principles of pathology. The students can either go the lab and work with cadavers or go on-line. The project was originally designed as a self testing tutorial. As an example of the complexity and detail offered, there are 70 full color images of the brain with 700-900 different labels. The school originally wanted to offer the course over the WWW but decided against it due to the time necessary to access complex medical images. Over the WWW each image required in excess of two minutes to download. The project required a healthy investment in time for the instructional development team and faculty to develop the CD ROMs.

(4) University of Illinois: Implementation of Virtual Classroom. The point of contact is Burks Oakley, Professor and Assistant Department Head of Electrical and Computer Engineering at (telephone 217-333-0716). The Virtual Classroom supports an Introductory Circuit Analysis course. It was funded by grants from the Alfred Sloan Foundation and AT&T. Students can work at their own pace on their own time with instant feedback. They communicate with faculty on the campus network. The course uses a software product called Circuit Tutor as the "text". Following each lecture students use Circuit Tutor to review and drill. They submit homework and take quizzes electronically. PacerForum bulletin board software is used as a conferencing system for interactions among students.

(5) Iowa State University: Virtual Reality Room. The point of contact is Jill Shanan, Iowa Center for Emerging Technology (ICEMT) Administrative Specialist at (telephone 515-294-3092). The project consists of constructing 12' x 12' room allowing researchers to mix physical objects with various virtual environments. Technology consists of two SGI Onyx computers with 8 MIPS, R10000 processors, a high performance point-to-point hippi network, 0.5 gigabyte of random access memory (RAM), four projectors, and seven mirrors. The room is located at the Iowa Center for Emerging Technology (ICEMT). Students and researchers can use the room for a variety of purposes. Examples include investigating interior lighting characteristics in a building before a brick is laid, development of warning and avoidance systems for cars, development of interfaces which allow humans to touch and feel virtual objects, to simulate environmental conditions (physics: letting an object fall if we let go), to enter a space and maneuver to see different views of a heavy object, to experience dangerous environments without being exposed to the actual danger.

(6) University of Pennsylvania: Making Robots Collaborate. The point of contact is Robert Mandelbaum, GRASP Lab (telephone 215-898-0351). This project is being conducted at the University’s General Robots and Active Sensory Perception Laboratory (GRASP). The purpose of the project is to investigate the development of multipurpose robots which can perform a variety of tasks including collaboration. Four robots freely move about the lab performing experimental tasks in which they must collaborate with each other. Communicating among the robots has proved to be a challenge, especially when transferring large amounts of data among robots. To achieve Ethernet connections between robots, Windata’s Freeport wireless LAN is used.

e. Distance learning.

(1) University of Notre Dame: Distance Learning for MBA Students**.** The point of contact is Rebecca Mela, Associate Director of Video Conferencing (telephone 800-631-3622 or e-mail: Rebecca.S.Mela.2@nd.edu). The project began in 1995 and was designed for business students geographically removed from the main campus. It began with two remote sites, one in Toledo Ohio and one in Hoffman Estates, Illinois. Both sites are run simultaneously with the distance learning site on the main campus. Audio and video is two way real time using a T-1 land line for delivery (vice satellite). The sites are traditional distance learning classrooms using Parker Vision tracking cameras, wireless microphones, an AMX control system with a touch

screen panel, Internet WWW access, and an assortment of peripherals including an ELMO document camera, a VCR, various microcomputers, graphics tools, and video monitors. Ameritech and VTEL developed the classroom.

(2) Texas A&M: Distance Learning Using a Satellite. The point of contact is Dr. Powell (telephone 409-845-2807 or e-mail: A-powell@tamu.edu). The project provides for multiple sites with point to point broadcast using satellite (C and Ku bands). Texas A&M uses the thumb rule 1" of diagonal screen for each viewer. For example, use a 25" monitor for 25 students. When there are more than 50 students use video projectors in place of multiple monitors. This project is an excellent example of satellite based distance learning. It was well received by the users and required lots of planning. The Web locator, for a good tutorial on distance learning and teleconferencing using a satellite as the delivery vehicle is http://agcomwww.tamu.edu/agcom/satellit/satlingo.

(3) University North Carolina: Distance Learning using ShowMe on the Desk Top using WWW**.** This project uses Sun's integrated ShowMe package. It provides a complete video, audio, shared whiteboard and shared application system which runs on Solaris 2.3 Unix systems. It is extremely configurable and has a clean well designed interface. It runs with an IP protocol so that it can operate across the internet. Reception of video can be done without any special hardware, just the ShowMe executable. Video capture requires a video board and camera. DT-5 team members at UNCC put together a page with some close ups of the ShowMe screens, ordering information, and some network utilization data captured during a video conference between UNCC and NCSU over the Internet.

(4) Cornell University: Distance Learning using CU-SeeMe on the Desk Top using WWW. CU-SeeMe is an experiment in providing real-time delivery or video and audio signals across the TCP/IP Internet. It was created at Cornell University to provide one-to-many connections using Unix reflector software. It does not use multicast, so the bandwidth increases with each connection to the reflector. There are plans to make it compatible with MBONE. The software is freely available across the Internet.

(5) Naval Post Graduate School: Distance Learning via Land Line. The point of contact is Harry Thomas, Distance Learning Technical Director at (telephone 616-256-2435 or e-mail: hthomas@nps.navy.mil). Unlike the University of Notre Dame’s T-1 land line, Monterey uses three ISDN land lines. Two traditional distance learning classrooms are configured for real time audio and video capable of broadcasting to eight remote simultaneous sites. The PictureTel 4000 Video Teleconferencing System is used with typical classroom peripherals to support the lecturing instructor. This distance learning site was piloted in 1994 and designed to meet future DoD needs at remote sites. Curricula is customized to suit the customer agency’s specific needs in area of advanced military technology, in engineering and applied sciences. Remote site students participate simultaneously real time with local site NPS students.

f. Mentoring and tutoring.

(1) Dartmouth College: Electronic Mentoring. Two points of contact include

Carol Muller, Project Director of Strategic Planning for the National E Mentoring Program (telephone 415-843-1352 or e-mail: carol.muller@dartmouth.edu) and Mary Pavone Director of WISP (telephone 603-646-3866 or e-mail: mary.pavone@dartmouth.edu). This electronic mentoring project is part of the Women in Science Program (WISP). The objective is to develop sustainable, cost effective support and knowledge from professionals in science and technology. Women undergraduate students are matched with mentor professionals in science and technology. The mentor provides guidance, career information, access to professional networks, and helps solve problems. The mentor and the student communicate using e-mail. This project, which will expand nationwide, received funding from various corporations. Foundation grants were provided by AT&T, IBM, and The Alfred Sloan Corporation.

(2) Georgian College (Barrie, Ontario Canada): Grammar Skills On-line. Two points of contact are Kathryn Cook and Trevor Davies (telephone 705-728-1968 ext 1626 or e-mail: kcook@gc1.georcoll.on.ca and tdavies@gc1.georcoll.on.ca). Their Web locator is http:/www.georcoll.on.ca. This project developed a remedial grammar course, "Techniques of Writing and Speaking", capable of being taught on-line using the Internet (Web). The program uses Logicus Software's 'Perfect Copy'. Logicus developed tailored software requested by the school. Students download assignments and upload completed work to their instructors. FirstClass computer conferencing software is used to conduct on-line discussions.

(3) On-line Writing Labs (OWLs) on WWW. Point of contact is Gary Zucca, Assistant Professor of Teaching Management and Organizational Behavior, National University in Los Angeles Calif (e-mail: gzucca@somt.nu.edu). Several universities participate in this project. Typical schools and the location of their OWLs include:

Purdue University On-line Writing Lab
 http://owl.english.purdue.edu
Dakota State Univ On-line Writing Lab
 http://www.dsu.edu/departments/liberal/cola/OWL/
University of Missouri On-line Writery
 http://www.missouri.edu/~wlec/writery.html
DeVry Institute of Tech On-line Writing Support Center
 http:/www.devry-phx.edu/Irnresrc/dowsc/
University of Michigan On-line Writing Lab
 http:/www.lsa.umich.edu/ecb/OWL/owl.html
Bowling Green State University Writing Lab
 http:/www.bgsu.edu/departments/writing-lab/Homepage.html

The project goal is to improve writing and research skills across the curriculum. Services at various OWLs vary widely depending on resources available. Examples of services include writing aids, on-line tutoring and critiques, grammar and style guides, tools such as dictionaries, and links to other writing and research aids. Major OWLs encourage sharing services through linking to their sites. Another excellent resource is the National Writing Centers Association whose Web locator is http://www2.colgate.edu/diw/NWCA.html.

g. Exploring teaching and learning methods.

(1) Duke University: Project CALC: Calculus as a Laboratory Course. The point of contract is Lawrence Moore, Co-Director of Project CALC (e-mail: lang@math.duke.edu). This is a project in cooperative learning using information technology. It is based on a three semester calculus program using the science laboratory model. Software was introduced to the course as students needed to solve more complex problems. Examples include Mathcad, Derive, MPP, and Surface Plotter. This calculus course allows students to learn by investigating real world problems cooperatively. The project is driven by the National Science Foundation's theory that calculus should become focal point of undergraduate curriculum. In this course students work on project teams. The classroom or laboratory focus is no longer on instructor, but on the cooperative learning team. The goals include solving real world problems with real data, emphasizing hands-on activities, discovery learning, writing, team work, and intelligent use of available tools. The text is *Calculus: Modeling and Application* by David Smith and Lawrence Moore. At present, emphasis is on the development of free standing interactive modules for follow on courses such as linear algebra, differential equations, and engineering mathematics. This project won the EDUCOM Higher Education Award for Best Curriculum Innovation for Mathematics.

(2) University of North Carolina at Chapel Hill: Enhancing Instruction with Multimedia. The point of contact is James Noblitt, Humanities Chair for Institute for Academic Technology. The project centered around authoring multimedia software to significantly enhance instruction with a goal of analyzing the impact of informational media on educational methodology. This is based on the theory that "The medium(format of information) is the method(teaching)". The project speaks to oral medium, print medium, image medium, and digital medium. It addresses the effect on basic learning processes by evaluating information technology's contribution to sequential learning, relational learning, and creative learning. Finally it looks at educational uses of media for validation of knowledge (oral medium), synthesis of knowledge (print medium), visualization of knowledge (image medium), and utilization of knowledge (digital medium).

h. Program integration and administration.

(1) Valley City State University (North Dakota): Improving Teaching with Technology. The point of contact is Ray Brown, Vice President for Academic Affairs (e-mail: ray_brown@mail.masu.nodak.edu). This project centered around the development of a Center for Innovation in Instruction which focused on applying emerging technologies to education. In particular the Center provides educators with professional development opportunities through workshops in technology planning assistance, networking, and product development. It is a source of current research as well as a preview center for hardware, software, and courseware. It was so successful that it quickly became the center for technology planning and training in the state.

(2) Harvard: IT Modernization of Business School (MBA program). This project is a complete integration of technology and the business of applying technology to an academic

curriculum. Originally the Business School used 6 e-mail systems, 77 desktop microcomputer configurations, and 8 networking protocols. The decision was made to consolidate and standardize with open technology using rapid prototyping development (RAD). Now when a Harvard MBA student logs onto the Intranet, a personal WWW page is created on the fly and class materials including assignments are pulled from Oracle databases and matched to the student's name. The students information is dynamic and can change every day. During the MBA course of study students participate on project teams with students from other schools. Classes become team oriented, on-line case studies are analyzed and discussed, simulations are run, and actual video is viewed from around world such as from China's sock-making plant.

(3)University Delaware: Computer Users Ethics Exam. The project consists of giving students an on-line computer ethics exam prior to gaining access to their account and the Internet. It has since been adopted by other institutions such as Harvard. It is called the Electronic Community Citizenship Exam. It quizzes students about e-mail, software licensing, passwords, etc. Failure means no account, no Internet, and no e-mail. Students are required to read a short manual before taking exam. The exam consists of twelve questions selected randomly from bank of 45.

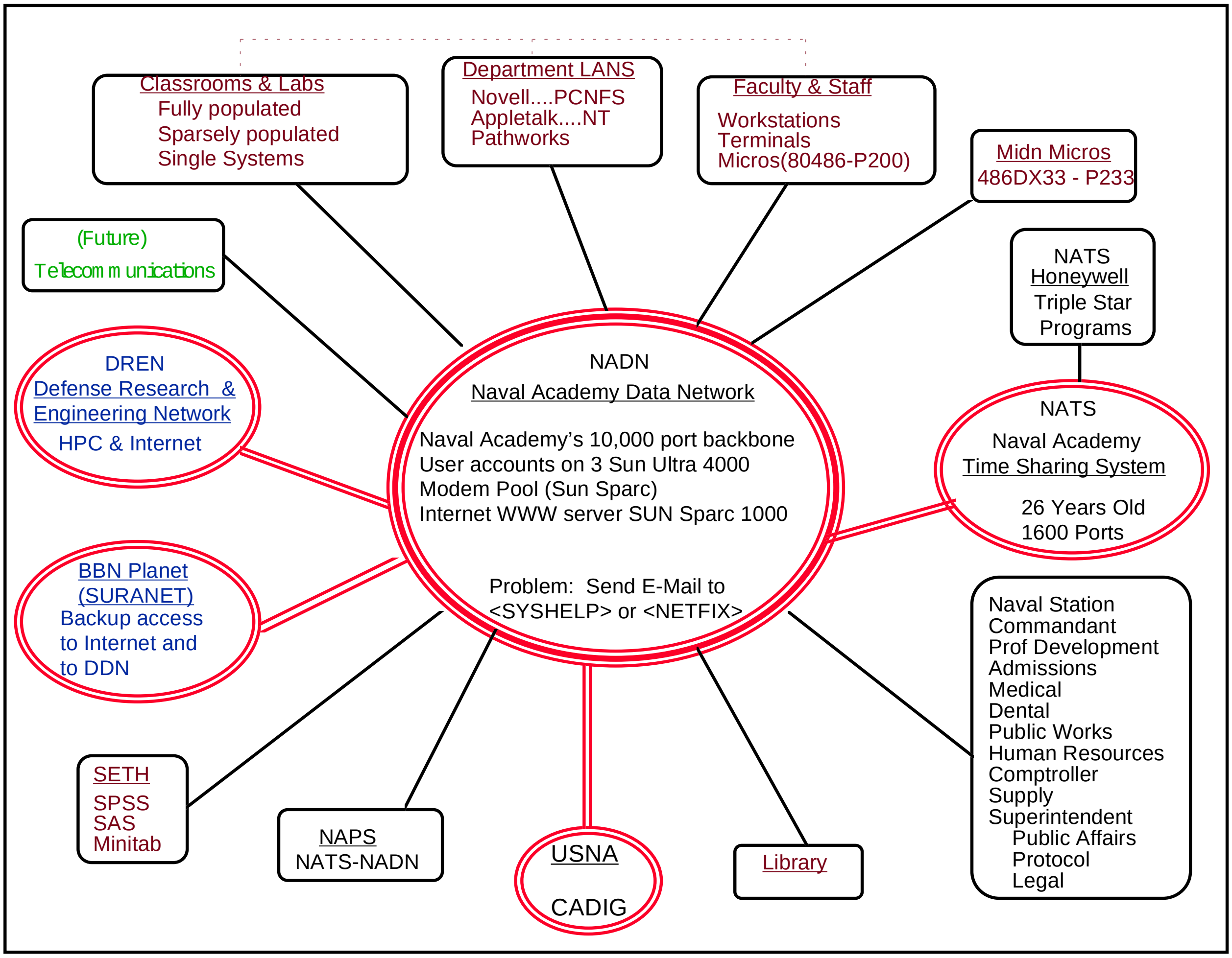
i. Professional training.

U.S. Merchant Marine Academy: Ship Handling Simulation. The point of contact is Dr. Joseph Puglisi, Director of the Office of Computer Resources. The Merchant Marine Academy is in the initial stages of planning for introduction of the Danish Maritimes DeskSim Bridge Simulation Trainer. This is a desktop version of the full mission trainer known as DanSim. It provides computer based training and instruction in most facets of ship handling including rules of the road, international regulations, basic hydrodynamic knowledge, instrument training, and cargo handling.

B. Technologies at the Naval Academy.

1. Description of the Naval Academy's complete technology environment.

a. Overview. Information technology equipment and products serve every building within the 600+ acre Naval Academy complex. In particular there is a variety of information technology throughout each department in the Academic Cost Center supporting Humanities and Social Sciences, Math and Science, and Engineering and Weapons. Fiber, coax, and twisted pair are common networking media indicative of age and technology. With no exceptions every institutional employee and student have access to every other employee and student via one of several data communications networks. Most offices, conference rooms, and laboratories enjoy connectivity. Gateways, routers, bridges, and switches allow networks to communicate with each other. Most administrative networks are homogeneous (same type) while various academic networks remain heterogeneous (different types such as a mixture of Novell and Appletalk). Hardware consists of one mainframe, several minicomputers of various varieties, a few hundred advanced workstations, and a few thousand desktop microcomputers. There is a preponderance of SUN and Intel based PC equipment. A variety of software applications is also prevalent. In addition to commonly used word processors, spread sheets, data bases, and compilers there are many discipline specific (support individual academic departments) software packages. The Naval Academy replaced its 60 year old Western Electric (WECO) analog telecommunications system with a modern AT&T ISDN system. The new system provides digital and voice mail services to every employee. Eventually it will be integrated with the data communications environment providing true multimedia throughout the complex.



b. Facilities. Facilities which accommodate and support some degree of computing include laboratories, electronic classrooms, departmental offices, conference rooms, Nimitz Library, and Bancroft Hall. The Learning Center (Halligan Hall), the Writing Center (Sampson Hall), and the Academic Center technology is configured similar to the standard electronic classroom and therefore not addressed separately.

(1) Automated discipline specific laboratories, such as those found in Physics and Chemistry, are common throughout academic and professional development departments. Most engineering and science departments have at least one laboratory. This includes the Mathematics Department. Most laboratories are networked. Within the Division of Humanities and Social Sciences, the Language Department has a nationally acclaimed automated language

laboratory. In addition to using interactive video as a teaching tool, it is served by real time worldwide computer controlled satellite input, providing a sense of realism not to be found in most language study programs. Most laboratories are computerized. Additionally, the Division of Professional Development has professional laboratories that are also automated. These laboratories represent applications to the naval service such as ship control and celestial navigation. Through software configuration, some laboratories can be easily used as a standard electronic classroom.

(2) There are two types of electronic classrooms. The first type is *fully populated* with a workstation for each student. Each is fully populated with desktop 80486 or Pentium microcomputers (with DOS&WIN or Win95) or SUN workstations (with Unix variant). Networked printing service is available. Most electronic classrooms have an instructor station with a projection system. Both SUN Workstations and microcomputer classrooms are available to support a variety of applications. These classrooms are geographically located to provide maximum utility to both students and staff. They are used to teach students, train staff, and serve as student study rooms when not formally scheduled for teaching or training. The second type is a *single system classroom*. This classroom contains one workstation for the instructor and one projection system or a large screen monitor for student viewing. Its primary use is lecture and demonstration. As an example, in Chauvenet Hall (Mathematics and Computer Science Departments) all classrooms not fully populated are single system classrooms. In other buildings departmental portable systems can accommodate those classrooms with no resident technology. Electronic classrooms add quality, excellence, and interest to the courses they support. Approximately 25 classrooms have between 5 and 17 systems while approximately 45 classrooms have a single instructor system.

(3) Major conference rooms have limited degrees of automation available. Most have local network access. Some have wide area access to the Internet. With one exception, none have resident computer systems with integrated projection systems. When computer systems are required, they are set up as necessary and removed immediately after use.

(4) Every office has both telecommunications and data communications capability for each occupant. Each faculty member has a minimum of one desktop PC available. Originally, faculty were provided Intel 80286 technology. Some have two systems (Unix workstation and Win PC). Over the past five years a concentrated effort was made to upgrade their desktop equipment to, as a minimum, be equivalent to the midshipmen they teach. This has been a problem in the past since the faculty equipment was purchased under a different set of rules using appropriated money, while midshipmen microcomputers were purchased using non-appropriated money. Most faculty have access to multiple networks including as a minimum NADN and their departmental local area network.

(5) In Bancroft Hall every midshipman room is equipped with one drop to the Naval Academy Data Network (NADN) per midshipman. This provides data communications to all midshipmen, faculty, and staff at USNA as well as access to the Internet and other academic departmental LANS. Each midshipmen purchases from the Naval Academy Store his/her own microcomputer with a standard software load. Bancroft Hall began a multi-year renovation

process beginning in the summer of 1994. During renovation each room will be wired for video, voice, and data communications. When integrated this will provide full multimedia capability turning their dormitory room into virtual environments.

Faculty and Staff Microcomputer Procurements FY 1989 - 1997									
Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
System Processor Speed Memory Hard Drive	Zenith 80286 8 mhz 1.1 mb 20 mb	Zenith 80286 20 mhz 4 mb 40 mb	EDS 80386DX 25 mhz 4 mb 40 mb	EDS 80386DX 25 mhz 4 mb 130 mb	EDS 80486DX 33 mhz 8 mb 213 mmb	EDS 80486DX 33 mhz 8 mb 345 mbm	EDS Pentium 75 mhz 16 mb 540 mb	ZEOS Pentium 100/133 16 mb 860/1.6gb	Micron Pentium 200MMX 32 mb 3.1 gb

(6) The Nimitz Library is fully networked. In 1994 the Library replaced an older GEAC system with a network capable Integrated Library System known as Innopac. It is hosted by a DEC ALPHA 3000 running the Unix operating system. In addition to Innopac the Library runs a Novell LAN. To provide further support to faculty and students, two fully automated bibliographic instruction (BI) rooms support faculty who wish to teach midshipmen in a library resource environment as well as support midshipmen use of the Internet. The rooms are networked electronic classrooms with access to the Internet and equipped with electronic white boards and presentation equipment including an ELMO document presenter.

Since this report deals with teaching and learning technologies, I have purposely omitted discussions of organizations and their functions such as Information Technology Services Division (ITSD), Computer Aided Design and Integrated Graphics (CADIG), Technical Support Department (TSD), and Technical Programs Department (TPD).

c. Hardware.

(1) Microcomputers. The most popular computer at the Naval Academy is the microcomputer. In addition to approximately 4,100 midshipmen micros purchased and owned by the midshipmen, there are approximately 5,000 additional micros used by the faculty and staff, located in offices, classrooms and laboratories. Midshipmen micros are either high performance 80486 machines or Pentiums. Most faculty microcomputers are either 80486 or Pentium. Notebook or laptop computers are a favorite substitute for those who travel. They are unfortunately expensive when compared to desktop technology. Most people who use a notebook computer regularly as a primary office system eventually require a bigger monitor, more storage, a full 101 key keyboard, more expansion slots for growth, additional disk drives, and speaker connections. The answer to this is a docking station. Docking stations are proprietary and can be very expensive. There is no reason why faculty members should be using anything older than 80486 technology. Each year, using the principles of life cycle management, microcomputers are purchased using government contracts to

Midshipmen Micrcomputers Classes 1997 - 2001					
Item	Class 97	Class 98	Class 99	Class 00	Class 01
System Processor Speed Memory Hard Drive Video CDROM	Zenith 486SX 25 mhz 8 mb 120 mb 512K None	Zenith 486DX 33 mhz 8 mb 200 mb 1 mb None	Zenith 486DX4 100 mhz 8 mb 420 mb 1 mb 4 Speed	Data Exp Pentium 166 mhz 32 mb 1.2 gb 2 mb 8 Speed	ACT Pentium 233 mhz 48 mb 2.1 gb 4 mb 8 Speed

keep the technology relatively current. During the past 30 months (FY95-97YTD) 1,440 microcomputers were purchased. Of those, 773 were for the Academic Dean Cost Center. This does not include microcomputers purchased for Professional Development Division or Physical Education. An additional 128 notebook computers were purchased during the same period, of which 58 were for the Academic Dean Cost Center.

(2) Workstations. There are approximately 250 advanced workstations (Unix) throughout the Naval Academy. They are used mostly as departmental LAN servers, laboratory computational and graphics machines, computer system administration and development machines, and special purpose machines. Most workstations at the Naval Academy run the Unix operating system or a Unix variant. Although there are HP, DEC, SGI, and SUN workstations at the Naval Academy, Sun is the workstation of choice. The popular alternative workstation is the SGI. It is an excellent graphics visualization machine and is the workstation of choice for a small number of academic departments.

(3) Minicomputers. There are in excess of 25 minicomputers throughout the Naval Academy. In various instances minicomputers are giving way to the powerful workstations. Minicomputers are used predominantly as enterprise servers. The most common older legacy minicomputer is the SUN 690 multi- processor. They are used in Ward Hall and in Rickover Hall. Other examples of minicomputers include the SUN Sparc Server 1000 used as the Naval Academy's Web Server, three SUN Ultra Server 4000s used as files servers for the Naval Academy Data Network (NADN), the Hewlett Packard 9000 used for midshipmen disbursing, and the three Data General Aviion 9500s installed as a cluster to replace the older Honeywell mainframe.

Obsolete Legacy Systems Popular in the early 1990's
SUN Sparc 1
SUN Sparc 1+
SUN Sparc 2
SUN Sparc LX
SUN Sparc ELC
SUN Sparc SLC
SUN Sparc IPC

Later Sun Sparc Workstations Purchased in Mid 1990s Excellent for Component Design & System Design				
System	Sparc 4	Sparc 5	Sparc 10	Sparc 20
# CPU	1	1	1	2
Speed	70 mhz	85 mhz	75 mhz	75 mhz
Memory	160 mb	256 mb	512 mb	512 mb
Disk Cap	28 gb	56 gb	138 gb	138 gb
Cost	$5K	$10K	$20K	$30K

Silicon Graphics Incorporated (SGI) Excellent Functional Workstation		
System	SGI Indigo 2 XL	SGI Indy 133
Speed	200 mhz	133 mhz
Memory	32 mb	32 mb
Disk Cap	1 gb	1 gb
Monitor	20"	17"
Cost	$17K	$11K

(4) Mainframe. The mainframe computer began as a GE 635 and evolved over 25 years through iterations to its present configuration as the Honeywell DP 8/70. A rapidly decaying system, it is labor intensive, has a high failure rate, and is neither functionally nor cost effective. Its failure rate is five times expected of that vintage machine. The machine is so old that technical and parts support are rare or non-existent, consequently when support is required, the Naval Academy will always pay a premium.

Minicomputers				
System	SUN 690 MP	SUN Sparc 1000	SUN Ultra 4000	DG Aviion 9500
Speed	45 mhz	50 mhz	167 mhz	50 mhz
# CPU	2	2	2	8
Memory	256 mb	512 mb	512 mhz	512 mb
Disk Cap	12 gb	12 gb	12 gb	44 gb

The mainframe hosts the Naval Academy Time Sharing System (NATS) Operating System (OS). It supports software systems for Administration, Faculty, Midshipmen, Admissions, Registrar, and the Commandant. The NATS(OS) can not support modern administrative fourth generation languages (4GL) application software. Current software systems consist of approximately 2,000 coded programs with eight million lines of procedural basic code, well above the designed capacity of the mainframe. Much of the code was written over many years by non computer professionals within many different departments at the Naval Academy, and not generated in accordance with any particular standard. Most of the data used is stored in VSAM files. Use of modern data bases is minimal.

At the present time this system is totally saturated (400% increase in usage from 1987 to 1992). As a time shared computer, when operating properly, it can accommodate 300-320 users. This is in an environment with 6,600 potential users, 500 - 1,000 whom demand use simultaneously. Additionally, today's computing needs are more complicated and demanding than they were as recently as 5 to 10 years ago. One example, Admissions routinely requires 15-20 % of the mainframe resources. A typical candidate query can take as long as 3 minutes. Although this may not seem long, 15,000 candidate queries, at 3 minutes per query, will take in excess of 3 months.

In 1993 the Naval Academy signed a multi-year contract with the Data General Corporation to replace both the Honeywell mainframe and its resident software with DG Aviion 9500's running a Unix (DG/UX) operating system. The new software system's architecture will emphasize use of a robust relational data base. A modified commercial-off-the-shelf (COTS) software system will provide the Naval Academy with its unique functionality. Appropriate development CASE tools will be used to customize the software while a natural query language will be employed by users who need to access the data base.

(5) Printers. With few exceptions all printers consist of impact printers or laser jet printers. Most of the impact printers are Epsons or Alps. They are being phased out at the normal end of their life cycle and replaced by more versatile and popular laser printers. Hewlett Packard and QMS are the most popular although the Academy does have a limited number of other units such as Texas Instrument. Once again printers are purchased from existing government contracts. They are readily available to everyone with computing access. Faculty and staff without a dedicated printer have access through a departmental printer server connected to their departmental LAN. There is also a limited number of high speed production printers and color printers such as those used by Information Technology Services Division.

(6) Miscellaneous Devices and Peripherals. There are several other devices and peripherals integrated in the normal office environment such as scanners, modems, cd-roms, and projection equipment.

d. Software.

(1) Operating Systems. Operating system software varies with the type of computer system. Unix variants, Microsoft products (DOS, Windows, New Technologies) Apple variants, OS2, and VMS are most common. Additionally, there are a few miscellaneous

proprietary operating systems such as Honeywell (NATS). Networks also have operating systems. The most prevalent LAN operating system is Novell's NetWare.

(2) Applications. Application software is the most diverse type of technology at the Naval Academy. There are three types of application software. Each type is illustrated below. The first type is a variety of *general administrative and general support software* such as word processors, data bases, spread sheets, etc. This includes academic support software such as communications software (i.e. Kermit or Procomm) and higher order languages (FORTRAN, BASIC, Pascal). The second type is *non-academic application software*. Although this software is targeted for many of the support departments such as Public Works and Comptroller, academic departments are required to use it. An example is FASTDATA, budgeting/accounting software required for use by every department at USNA, including academic departments. The third type is *academic discipline specific software*. This is found primarily in the academic departments and complements the courses being taught. All categories are used by the Academic Dean Cost Center including over 30 specific licensed applications consisting of computational, graphical, modeling, simulation, mathematical and statistical, and design software. To emphasize software's contribution to teaching and learning, a short description of the academic discipline specific software follows:

Engineering and Weapons.

Satellite Tool Kit (STK). This took the place of the older Space Lab software. STK is used to generate orbits and to predict behavior to support design and analysis of space craft.

I-Deas is used to heavily support design projects in EM472 and EM477. It is a solid modeling package with good analysis support. Many midshipmen design presentations will include output from this software.

General Administrative Software	
PC Software Category	Windows Platform
Internet	Mosaic
	Netscape
	Ethernet
Communications	Procomm Plus for Win v.1.02
	Nov*Ix
Mail	NADN Mail
	PC Pine
	GroupWise (WP Office)
Scheduler	GroupWise (WP Office)
Word Processing	Word Perfect for Windows v.6.1
	MS Word (MAC)
Spreadsheet	QuattroPro for Windows v.6.0
Database	Paradox for Windows v.5.5
	dBase IV for Windows
Presentation Graphics	MS PowerPoint
	QuattroPro for Windows v.6.0
	WordPerfect
Project Management	MS Project
Virus Protection	Data Physician 4.0e
Utility	Norton Utilities v.8.0
	PKWare
Languages	True Basic
	Borland Products
Groupware	Novell Groupwise

Non Academic Application Software	
Facilities Maintenance	
	PWMA
	ALPHA
	PC TRANSPORT
	TRANSPORT
	BEST
Ship Maintenance (Yard Patrol Craft)	
	MRMS
Supply and Finance	
	ILSMIS
	FastData
	PC Payroll
Medical	
	Telemedicine
	Dentrix
Administration	
	FedForms
	Audit
Professional	
	MILFACTS
	FitRep

Academic Discipline Specific Software		
Eng & Weps	Math & Science	Hum/SS
Satellite Tool Kit	MATLAB	SAS
I-DEAS	Island Draw	SPSS
FLOWTRAN	MAPLE	Automax
NASTRAN	Mathematica	Centennia
CFD-ACE	Exceed	PC Globe
ABAQUS	MasPar	CompuStat
EASYPLOT	ProModel	Image Pals
DESQview	CPORS	GAHM
MATHCAD	Gaussian92	FAIRMODEL
	RSMAS	Limdep
	MPP & MPP3D	
	Alchemy III	
	SPARTAN	
	MolEN	
	Publisher	

FLOWTRAN which is part of the ANSYS package replaced FLUENT, an older finite element package for fluid flow analysis. Student projects and faculty research often require this software.

NASTRAN is a large industrial package. It has limited use in aircraft design courses and replaced GIFTS, an old structural analysis package which is no longer supported.

CFD-2000 or CDF-ACE is the current finite element software of choice within the Aero department. ACE was used for the first time this past semester in a new finite element course.

Abaqus is a non-linear finite element package used primarily to support research in composite material analysis, primarily in mechanical engineering.

EasyPlot is owned by several faculty members to support graphics.

Mathcad is an equation solver package that is also used as an electronic chalk board. It is used in mechanical engineering and aero engineering for classroom demonstrations and student assignments.

Mathematics and Sciences

ProModel is simulation software used by the Math Department to teach Discrete Simultaion. This course was originally taught using a mainframe language GASP and then migrated to the microcomputer application SIMAN.

Mathematica provides an environment for doing just about anything imaginable with mathematical expressions. It includes facilities for editing text, evaluating and graphing equations, programming, and organizing mathematical experiments into coherent documents.

MAPLE is a competitor to Mathematica. It has a plot-tools package that brings Maple close to Mathematica's graphics capabilities; enhanced differential and partial differential equation-solving; enlarged the special-functions libraries to handle most physics and engineering cases; and added tensor analysis.

MPP is a math plotting package used to graph.

CPORS (Cooperative Project in Oceanic Remote Sensing). Under a memorandum of agreement between USNA and NOAA a computer based laboratory is maintained for the collection and analysis of environmental satellite data. CPORS and RSMAS (University of Miami application software) software support this lab.

Matlab is used as a matrix manipulator and support for systems analysis.

Gaussian 92 is a Molecular Orbital Calculation program used to perform both semi-empirical and ab initio calculations on both simple and rather complex chemical systems. It has found a use in Organic, Physical, and Inorganic courses but mainly used by faculty and mids as a research tool.

SPARTAN is another and more widely used Molecular Orbital Calculation program. Similar to Gaussian in capability but has been tailored much more to the graphical platforms such as SGI. Outstanding visual tool for organic, physical, and inorganic students as well as being used in reserach with midshipmen.

Alchemy III is a good visual tool for molecular modeling used in organic chemistry. Students use it quite a bit in this course. Does not have the calculational power of SPARTAN or Gaussian. Does have some ability to do molecular mechanics types of calculations.

MolEN is used by crystallographic students, few in number, which allows for crystal structure solution and presentation.

Humanities and Social Sciences

SPSS is statistical software for the Social Sciences. It contains procedures for file management, data management, report summaries. It offers a wide range of statistical techniques including frequency distributions, descriptive statistics, analysis of variance, correlation analysis, regression, non-parametric tests, and modeling statistics. It is used in Political Science, Economics, and Leadership and Law (psychologists).

SAS is a statistical package functionally similar to SPSS. Excellent tool for statistical research. It is used by Economics faculty for research and by 1/C Economics majors in Research Seminar (FE475).

COMPUSTAT consists of income and expenditure data as well as price and dividend data on corporations in the United States. It is used for faculty research and in Research Seminar (FE475) and Financial Analysis.

FairModel is an economic model of the U.S. economy with which a wide range of policy simulations and forecasts can be done. It is used in Macro Economics (FE365) as the basis for the laboratory associated with the required major course.

LIMDEP (Limited Dependent Variable) is a sophisticated statistical software program. It provides estimates of multiple regression, logit, probit, nested logit, etc. It is used in Economic Statistics (FE331) as the basis for the regression analysis in the Research Seminar (FE475).

Automax is menu program used on all Economics machines in Nimitz97 and in the Economics Department.

Centennia is an on-line historical atlas covering Europe, North Africa, and the Middle east from 1000AD to the present. It contains dynamic maps showing all dynastic and political boundary changes. The zoom feature allows the user to examine regions for any year or tenth of a year. Additional features give historical explanations for political changes and provides mechanism to search for, define, and locate major events, places, persons through this 1000 year period. Since 1993 this has been issued to incoming plebes and used in the three core history courses (HH205 and HH 206 - Western Civilization and HH104 - American Naval Heritage). It has limited use in some upper-level history courses and in some Political Science and English courses.

PC-Globe is a contemporary atlas of all countries in the world containing political and topographical maps as well as extensive demographic, economic, and social data. Software is available in History classrooms and in the Library. It is used occasionally by some instructors in History and Political Science for homework assignments.

Great American History Machine (GAHM) provides map display of county-level US Census data from 1790 to 1990 and for Presidential, Senatorial, and Congressional election data from 1844 to 1984. It includes all gender, race, ethnic, age, economic, and social data collected by the Census Bureau. It can examine small geographic areas and display canals, railroads, roads, and major rivers. This software is available through an Academy wide site license. It is used for major term paper assignments for the three upper-division History courses(approximately 100 students) and for special projects.

ImagePals is an image management and display program which allows images to be scanned, edited, and enhanced, and placed in "albums" for future use. Primary use is by History faculty to store and display images for classroom presentations.

e. Communications. Communications environments consist of institutional data networks, localized or departmental data networks, global networks and telecommunications (phone systems).

(1) Data Communications. There are three major-area data communication networks at the Naval Academy. They consist of the Naval Academy Data Network (NADN), USNA, and FISHNET. There are several departmental local area networks.

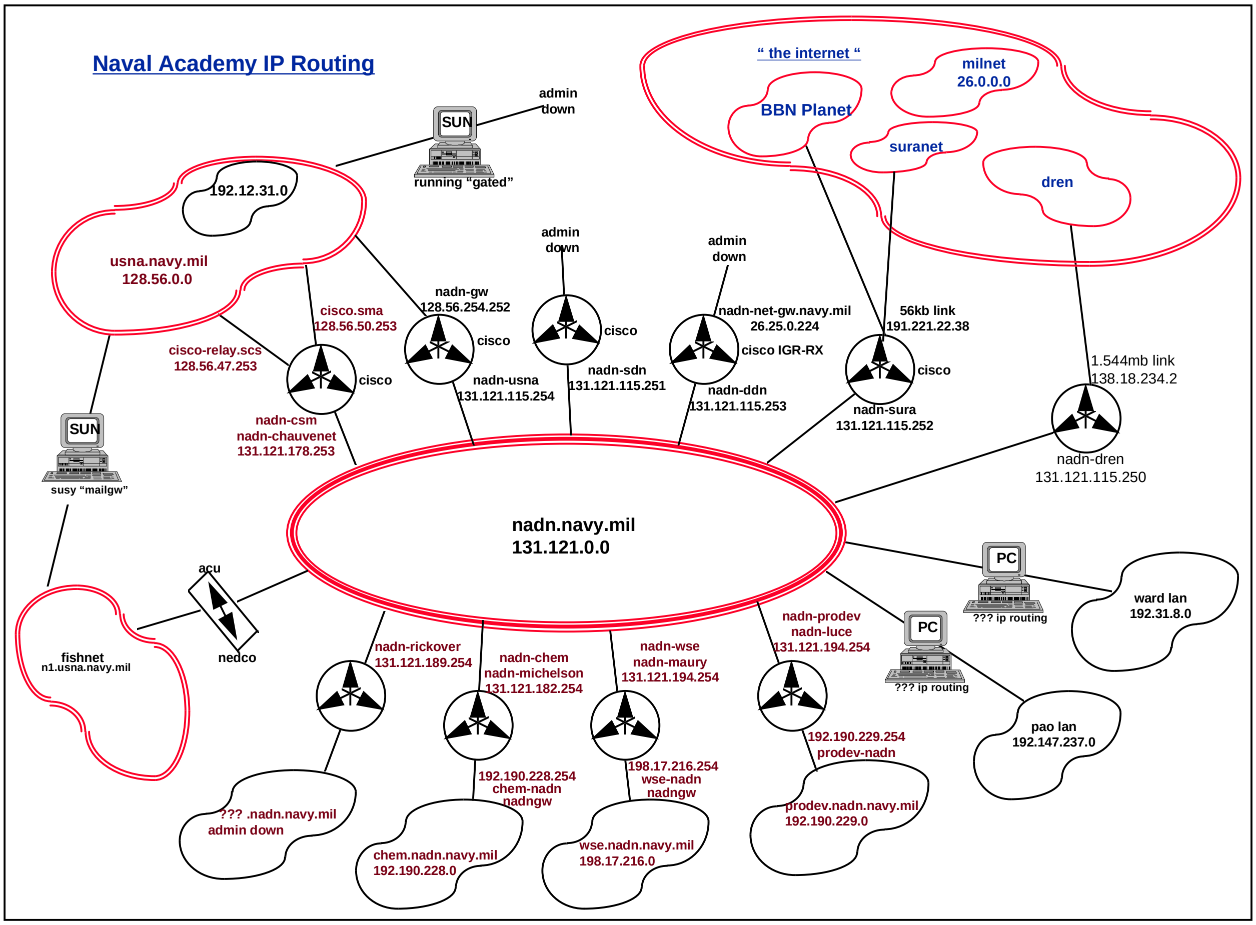
(a) NADN. This is a character based, multi strand fiber TCP/IP network designed in 1987 and installed by TRW. It has 10,000 ports. Originally 9,000 ports were serial and 1,000 were Ethernet. NADN took three years to install and was finally accepted by the Naval Academy in May 1992. During the five years of competitive government procurement, design, and installation, available network technology and standards radically changed creating a need for a near term upgrade. NADN is the first campus wide network designed from the bottom up. When fully developed, NADN will be multimedia capable. The plan is to integrate the USNA and NADN networks, discontinue FISHNET, and integrate the ISDN voice technology. As of June 1994 all institutional electronic mail migrated from NATS to NADN. Every Academy computer user has an account and e-mail on one of three SUN Ultra 4000 file servers. National and international wide area access is via the Internet. Prior to 1993 Internet access was gained through the Defense Data Network (DDN). Academy changed Internet access to the Defense Research Engineering Network (DREN) and subscribed, for backup, to the Southeastern United States Research Net (SURANET), now known as BBN Planet.

(b) USNA. The first to be installed was the Division of Engineering and Weapons' USNA network. It started as a research project in the early 1980's and eventually grew to provide various levels of support to many of the Academic departments. As the electronic laboratory and classroom environments grew it provided necessary connectivity. It originally hosted a 19 Kb SUN Gateway to the DDN from which access to the Internet was gained for midshipmen and faculty research. This has since been replaced. Access to the Internet is now through a CISCO Gateway located in Ward Hall.

(c) FISHNET. FISHNET was the first institutional attempt to provide networked connectivity to all major buildings at the academy, beginning with the academic buildings. Fishnet was designed and built by ITSD personnel. It has 1,340 drops and provides connectivity to the Honeywell mainframe. Network interface was originally through NEDCOs (New England Digital Company) devices. Even though most interfacing is done via the newer Texas Instrument Advanced Connector Units (ACU) provided when NADN was installed, 41 NEDCOs remain in various buildings, including five located at the Naval Academy Preparatory School (NAPS). When the Data General Aviions are fully operational the Honeywell will be retired and FISHNET will be discontinued.

(d) Local Area Networks. Over the last five years several LANs have been installed to support user needs. More than 80% of the user communications and data needs reside physically within their departments. Consequently, LANS provide tailored support for several special business functions such as the Public Affairs Office. Since there is such a variety of departmental software applications and hardware systems, there is also a corresponding variety of LANS. There are over 60 local area networks at the Naval Academy. LAN users communicate readily with other LAN users over NADN. Academic departments communicate freely on over 35 different Novell, Appletalk, PCNFS, and Pathworks connecting approximately 400 offices and 75 information technology facilities such as electronic classrooms, labs, and productivity rooms.

(2) Telecommunications. The Naval Academy is currently using its AT&T 5ESS ISDN digital phone system. It replaced a 60 year antique Western Electric analog switch. The old switch was unreliable, unexpandable (3,100 lines), costly (approximately $1,000,000 annual lease and maintenance costs), and incompatible with any of the modern technology requirements of phone systems. The old switch also serviced the Naval Station and various tenant commands such as the medical clinic and David Taylor Research Center. Over the years several key-



switches were installed to give more reliability and the appearance of digital technology. The key switches (excellent example of sub-optimization) collectively over taxed the main analog switch, often times rendering it incapable of answering user demand for such services as outside lines and long distance service. The new system offers over 100 features such as call forwarding and voice mail. Main components consist of a main 9,720 line digital switch located at the Naval Academy in Mahan Hall, an auxiliary 2,000 line switch at the Naval Station, and a one-of-a-kind fiber submarine cable, crossing on the floor of the Severn River, providing fiber connectivity between the Naval Station and the Naval Academy. This provides real time data and telecommunications capability between the two organizations, facilitating professional training for midshipman, that was in the past conducted with much difficulty. The new phone system provides opportunities for interesting academic applications such as distance learning. This would allow USNA, other Service Academies, and other universities to share academic experiences, lectures, and research that would otherwise might be cost prohibitive. Limited cellular communications is available for mission critical use.

2. Teaching and learning technology efforts. Information technology is used in every academic department for both teaching and research. Indications of productive use include: the 13,000 pages on the Naval Academy's Web site, several of which are teaching and learning sites for midshipmen; the academic departmental local area networks linking classrooms, laboratories, and offices; and system decision papers provided by each academic department detailing their projects in support of core courses, majors courses, laboratories, accreditation, and research.

a. Naval Academy. There are two categories of projects which contribute to teaching and learning. The first category is a project which automates course work which is already being taught, or has technology as the subject matter. These environments improve the quality of education every year. The second category consists of development projects specifically to improve teaching and learning. An excellent example of continuous use of technology to teach and to learn is the use of software previously illustrated.

(1) Division Overview. Each year academic departments submit an Abbreviated Systems' Decision Paper (ASDP) which highlights resources required to support information technology initiatives. The ASDPs provide an excellent summary of existing use of IT to support teaching. A brief summary follows:

(a) Engineering and Weapons. In the Division of Engineering and Weapons, Aerospace Engineering concentrates on improvements to well established electronic classrooms, Aero and Astro Labs, Spacecraft Design Electronic Classroom, Mission Control, and the Satellite Ground Station. Weapons and Systems Engineering (W&SE) emphasizes a systems approach to applying information technology to the entire department. This includes providing complete local area network connectivity to classrooms and labs with a central server hosting a majority of the courseware. Other well established W&SE projects include Analog Systems Simulation, Robotics Computation, Digital Technology, Systems Identification, and the aggressive use of multimedia including Smart board technology in the classroom. Electrical Engineering emphasizes the majors' labs (Fusion and Fiber Optics) and electronic classroom development including use of mobile demonstration carts for classrooms with limited technology. Mechanical Engineering utilizes data acquisition and emphasizes modeling for design work. NAOME focuses on labs such as Marine Propulsion, Nuclear, Life Support, Hydrodynamics, and Ship Structure as well as innovative classroom presentation development such as creative applications of Quattro Pro.

(b) Mathematics and Science. The Division of Mathematics and Science emphasizes electronic classroom and laboratory development. Mathematics continues developing Massive Parallel Processing and software applications for many courses such as calculus and discrete simulation, while Chemistry uses molecular modeling in the classroom and laboratories on both powerful workstations and desktop microcomputers. Physics is well known for laboratory automation throughout the curriculum using a Apple products and classroom innovation using such products as ClassTalk and mobile demonstration carts. Computer Science speaks for itself. The discipline is the technology. It is a hands on curriculum with heavy lab emphasis in such areas as computer graphics and robotics. Microcomputer labs are available for all courses taught. Oceanography is unique. It supports various information technology based labs including the CPORS Lab (Cooperative Project in Ocean and Remote Sensing), the Oceanography Lab, the Meteorology Lab, and YP686 automation for data gathering and analysis.

(c) Humanities and Social Sciences. The Division of Humanities and Social Sciences share resources such as electronic classrooms. As a group they develop their different levels of multimedia for the electronic classroom. Faculty acquire skills and tailor classroom products using suites of staff productivity tools consisting of both hardware and software. Each department has unique applications specific to their discipline. English has a Writing Center. Languages use a satellite feed into an interactive classroom system. History develops resources for the Web and using products like PC Globe, Centennia, and the Great American History Machine. Economics emphasizes statistical analysis packages running on Unix platforms, some shared with Political Science, and econometric models and simulations.

(2) More Recent Developments. The following are an example of more recent development within some of the divisions and departments:

(a) Nimitz Library Bibliographic Instruction Rooms. This expands the Integrated Library System (Innopac) to include to Bibliographic Instruction Rooms. The classrooms serve two purposes. First, it faculty can teach a portion of their course in a state of the art multimedia electronic classroom with wide area access to the Internet. Second, students learn how to complete research assignments using on-line resources including the Library's Innopac System and the Internet. The classrooms have 16 student workstations loaded with the latest software, an instructor station, electronic white board, ELMO, computer driven projection system, and ClassNet. Upon completion both classrooms will be connected by video teleconferencing technology. Point of contact is Dr. Richard Werking.

(b) E Mentoring. Although this project is in the infancy stages, it will provide an opportunity for math students taking calculus courses to receive on-line mentoring. The principle vehicle is NADN's e-mail system. The point of contact is Professor Carol Crawford.

(c) Intranet-Internet Resource Development. There is a wealth of USNA Web site development to support teaching and learning. As an illustration, the history department has developed an instructor resource site for their Western Civilization Course. The site contains excellent information for both instructors to prepare their lectures, and for students to research their assignments.

(d) Spreadsheet Technology. Although spread sheets are used for many purposes through the curriculum, the most creative project is in NAOME where it used by one professor for every engineering course he teaches. He teaches in an electronic classroom using the Quattro Pro application to teach computational methods, graphics, graphic analysis, comparative analysis (for economics), and visualization.

(e) On-line Exams. EM477 and EM371 students must take typically 8-10 exams throughout the course. They take the exams when ready. Once taken, the exam is submitted to the computer and graded for immediate feedback. Point of contact Asst Professor Miner.

(f) Electronic Tutoring for Physics. This is an ONR sponsored collaborative effort between the University of Pittsburgh's Learning Research and Development Center and the Naval Academy's Physics and Computer Science Departments. They are developing a tutoring system, known as ANDES, to help students learn physics. ANDES, which includes several varieties of feedback and evaluation during coached problem study and solution, is based on the latest research in Cognitive Science as well as recent instructional reform in teaching physics. When completed ANDES will be used at the Naval Academy to enhance learning in the introductory physics course SP211, taken by approximately 1,000 students per year.

(g) Enterprise Networking. ITSD is migrating USNA's enterprise NADN network to an asynchronous transmission mode (ATM) network. With the explosion of hardware and software technology capable of delivering full multimedia color applications in areas of computational analysis, graphics, and 3D visualization, a character based backbone configured network with 10 megabits shared bandwidth is inadequate. The project consists of migrating to an ATM using an optical carrier protocol (OC-3). The backbone will be a logically re-architected star topology. The project includes complete redistribution of existing local area networks, and development of an Internet/Intranet architecture which will provide networking functionality across the Web. When the migration is complete, faculty and students will be able exchange complex data and information in their native format, real time, in support of teaching and learning.

(h) Central Facility Project. This project replaces the Honeywell mainframe and the 8 million lines of procedural code with an Oracle relational database. All faculty and students who are required to access administrative support programs (i.e. Grades ***, Registration ***, Absent ***, etc.) will be able to do so in a windows format compatible with the typical desktop environment. Faculty will have query tools such as Business Objects which will allow them to query data real time, not accessible in the past. The Honeywell is limited to approximately 300 simultaneous users. The new system will allow access on demand by all users simultaneously.

(i) ClassTalk. ClassTalk is one of three Physics Department automated classroom efforts. It supports 24 students and adapts to the typical Plebe calculator. It is a polling system used by the Physics Department to teach. The instructor asks a question and students respond without disclosure. It encourages classroom participation especially for the shy or timid student. This facilitates learning through classroom participation. The system allows the instructor to quickly survey concept understanding and record and analyze the responses on the fly during the lecture. One can quickly switch to demonstration programs on the host computer or play video clips. Students are much more involved and appear to be enthusiastic about the polling. This project is similar to the Professional Development project using Respondex to accomplish to same functionality. Point of contact is Professor Shelby.

(j) Classroom Design. Professional Development Division has been experimenting with a total integrated classroom system with includes full motion multimedia, polling with the Respondex System, and networking.

b. Naval Station. The Naval Station plans the development of a Learning Resource Center. The project provides an electronic classroom used principally for interactive in-rate training for enlisted personnel. Once completed, the initiative will include exporting training products on-line from CNET to support all rates and ratings. Opportunities will be available for self study using CD ROM products and organized classes led by an instructor.

c. NAPS. NAPS is currently upgrading their entire integrated technology environment. This includes network local area network wiring and developing methodologies and teaching products to use in the classroom. Their biggest effort is developing Internet technology. NAPS has a dedicated 56K frame relay connection to the Internet through the DIGEX Corporation. Networking and Internet access will provide better library access and supportable and dependable technology in the classrooms.

C. Suggested Technologies, Methods, and Resources.

1. Teaching and learning technologies best suited for midshipmen use. Teaching and learning technologies best suited for midshipmen include video teleconferencing, broadcast television, electronic classrooms and laboratories, multimedia courseware, World Wide Web (WWW), visualization, virtual reality, intelligent tutors, and voice synthesis.

2. How selected technologies can be used to teach.

a. Teleconferencing.

(1) Satellite Delivery with Compressed Digital Video (CDV). Use satellite delivery distance learning to offer graduate courses to in-house students (update knowledge of officer instructors, gain a head start on graduate programs, support research projects or special courses). Utilize for non-credit and training short courses to faculty and staff.

(2) Land Line Delivery using T-1 or ISDN. Enhance learning using group efforts and group projects between both faculty and staff at the service academies and other institutions. Share instructional load between institutions. Support extra instruction (EI) and review for midshipmen as needed. Move towards distance education that utilizes asynchronous desktop teleconferencing using high-speed networks over land-based broadband lines. Encourage students to work at their own pace with continuous assessment.

b. Broadcast television. Complement lectures, create lab simulations, and perform assignments such as foreign languages. Access video during normal class time. Allow midshipmen to view video on their own schedule through their workstations in Bancroft Hall.

c. Electronic classrooms and laboratories. Hands on use of computers by midshipmen during class or lab periods to write software, use equation solver software, begin composition of expository essays, analyze data, create and run simulations and animations, and manipulate high end workstations. Use of electronic polling systems to provide in class student feedback, facilitate discussions, and record information on student attitudes, understanding, and participation trends. Demonstrate and allow midshipmen to experiment with software systems they will eventually execute on their own in Bancroft Hall.

d. Multimedia courseware. Use both in-house and externally produced multimedia productions to create highly effective presentations for in-class use, to support interactive and cooperative classroom learning, and for distance learning, whether across the Yard or across the country. Provide flexible customization opportunities to accommodate differences in goals, abilities, learning styles and academic preparation. Bring the best lectures and learning modules to students anytime inside or outside the classroom.

e. World Wide Web. Use of hyperlinked, interactive, electronic textbooks or course syllabi linked to text, images, sound, video, charts, etc. for study before and after formal class periods. Makes available solutions for study using multimedia technologies. Execute assignments requiring acquisition of text, numerical data, images, and video from many diverse sources inside and outside of the Naval Academy.

f. Visualization. Provide enhanced opportunities for visual presentation of the physical world, man made environments, past and present societies, and mathematical systems. Offer animation and modeling systems for both instructor and student use. Provide technologies that allow students to ask "what if" and "how can" questions and give them the greatest flexibility to manipulate past and present natural, mathematical, and social systems.

g. Virtual reality. Allow students to experience three dimensional natural, mathematical, and social worlds that practically speaking cannot be visited in person. Place students in realistic "virtual" environments, such as, a modern battlefield, the cockpit of a modern aircraft, command center of an Aegis cruiser, a meeting of a past Soviet Politburo, or the main street of a medieval town.

h. Intelligent tutoring. Use asynchronous WWW technology to provide an environment (delivery vehicle) for students to receive assistance from a computer tutoring program which not only corrects student mistakes but analyzes the students’ attempts at problem solving and offers assistance in a variety of forms including multimedia presentations. Intelligent Tutors incorporate a knowledge base of the subject matter and a rules based programming language which allows the computer to mimic an expert human tutor in the field. Students receive a form of EI on demand in the instructor’s absence.

i. Voice synthesis**.** Improve efficiencies in man-computer communications. Input-output systems for computers have migrated from the keyboard to the mouse. The next command input to computer will be the human voice. Voice synthesis will provide yet another dimension to control opportunities.

3. Methods for developing, integrating, & implementing these technologies.

a. Teleconferencing

(1) Satellite delivery with compressed digital video (CDV). Procure an antenna Ku band CDV and distribute signals over NADN. Work closely with NPGS and other graduate institutions to deliver appropriate credit courses. Coordinate short course offerings to obtain the greatest exposure.

(2) Land line delivery using T-1 or ISDN. Either dedicated T-1 or ISDN will provide the connectivity between institutions. NADN's upgraded ATM backbone will provide high bandwidth capability for teleconferencing. The emerging digital infrastructure will have the capability of transmitting multiple streams of television quality video in real time and allow transmission of classroom material containing recorded video and audio between computers in a few seconds or minutes.

b. Broadcast television. Provide student and faculty access to AMX systems that will allow asynchronous use of both stored video and real time TV. Continue to receive broadcast TV programs from satellite and cable sources.

c. Electronic classrooms and laboratories**.** Current electronic classrooms (and all classrooms) need access to broader band communication networks and delivery systems to allow full multimedia use. In the future midshipmen may be able to bring their own notebook size computers to class and replace the need for fully equipped electronic classrooms. Include appropriate communications infrastructure and architecture in renovated buildings so that future needs can be accommodated and classroom spaces can be configured with hardware specific to courses and disciplines.

d. Multimedia courseware. Commercially acquire robust, flexible, complete multimedia applications, as well as authoring packages best suited for faculty developmental work and student utilization.

e. World Wide Web. Focus on high speed communications networks within USNA and to the outside world. Delineate best uses of Internet and Intranet for instructional applications. Store class related material on a server accessible via the World Wide Web or FTP. Make use of ATM connections to the server to allow a full multimedia presentation to be downloaded to a user computer quickly.

f. Visualization. Identify and acquire animation and modeling packages and languages such as HLMPL's (high-level mathematical programming languages) best suited for faculty developmental work and student utilization.

g. Virtual Reality. Identify and acquire appropriate virtual reality hardware and software systems. Work toward virtual reality developments that utilize standard faculty and midshipmen computers.

h. Intelligent Tutoring. As part of a larger collaborative effort with faculty at Carnegie Mellon, continue current experimentation in Physics and Computer Science Departments at USNA toward the development of Intelligent Tutoring modules for electricity and magnetism portions of the 3/C physics course. Explore applications in other disciplines.

i. Voice synthesis. Add voice recognition and activation systems to faculty and student workstations when they become cost effective.

4. Resources available and obstacles to overcome.

a. Teleconferencing

(1) Satellite Delivery with Compressed Video (CDV). Current satellite reception is limited to analog rather than digital signals. Added CDV capability can take advantage of current distribution system which can direct signals to most places in the Yard and eventually to midshipmen owned PCs in Bancroft Hall. Government installations already have access to some educational products on the Satellite such as NTU (National Technological University) without the initial hook up fee; only tuition fees are charged.

(2) Land Line using T-1 or ISDN. Global standardization, public policy, regulation and other issues of national strategy are still being sorted out in the telecommunications field. Application software to manage and facilitate telecommunications bandwidth limitations are being solved. Faculty education and motivation will be key issues once changes in pedagogy become possible. Teleconferencing technologies may call into question traditional teaching methods in departments where 8-10 faculty members give the same lecture 20-25 times during a single day to large groups of students. Once the best lectures become available across classroom and departmental boundaries, more faculty may become involved in mentoring, certifying, and advising rather than repetitive teaching. In some fields, it will be easier to serve other educational needs within the fleet and the Navy at large.

b. Broadcast television**.** Current ERC cable plant provides minimal quality analog video delivery to classrooms and receives extensive use by some departments. Expanding the number of ERC channels available through NADN would dramatically increase the times and places traditional video products could be viewed, including midshipmen rooms during non-class hours. AMX digital equipment, which provides far greater delivery flexibility, can utilize the existing NADN system but will be further enhanced with forthcoming ATM upgrade.

c. Electronic classrooms and laboratories. Nearly all departments at USNA utilize some form of electronic classroom or electronic laboratory although applications vary widely, including: interactive video labs, image and sound display, and software demonstration in the humanities; image display and polling in Professional development; statistical analysis and societal simulations in the social sciences; networked high performance computing and satellite monitoring and control in engineering; data gathering and instrument control in the sciences. Maintaining currency remains the toughest obstacle.

d. Multimedia courseware. Long established notions of teaching productivity and effectiveness will be barriers to the use of courseware for teaching and learning. Operationally meaningful teaching and learning objectives must be re-assessed by the faculty in high technology environment. Faculty autonomy will be challenged and a new vision of learning and teaching productivity will be debated. Current traditions of evaluation and reward for faculty promotion may also provide barriers to faculty participation. Where distance learning technologies are appropriate, teaching methods which de-emphasize lecture delivery may be preferred.

e. World Wide Web. Serial-only connectivity in most midshipmen rooms discourages expanded instructor and student use of Web-page-based delivery of course materials. Easy to use, non-technical Web page authoring software must be available to all USNA instructors; short courses, training seminars, and summer support for faculty development work are also essential.

f. Visualization. Presently SGI and SUN workstations provide animation and modeling visualizations of DNA molecules in chemistry and vibrations in engineering. Midshipmen in engineering design classes use modeling to communicate design ideas. Animation could have significant impact in core cores such as plebe chemistry but length of developmental time hinders implementation.

Distance Learning Pays for Itself	
Recapitalization	$2,000
Technical Support Salary	$2,500
Faculty Salary	$7,500
Administrative	$1,000
Course Development	$6,000
Communications	$3,000
Total	$22,000

g. Virtual reality. Only very limited explorations have taken place at USNA to date but opportunities for developments in nearly all disciplines will be possible in the future. Development time will be a significant problem.

h. Intelligent tutoring. Most obstacles here are in the development of sufficient knowledge bases to assure the intelligent aspect of tutoring. The programming languages exist and are continuously being refined. Delivery will be over NADN via departmental servers.

i. Voice synthesis. While nothing at USNA restricts its use and there is currently little demand for it, this technology will find its way into our environment as a tool resource in the same manner as the mouse has.

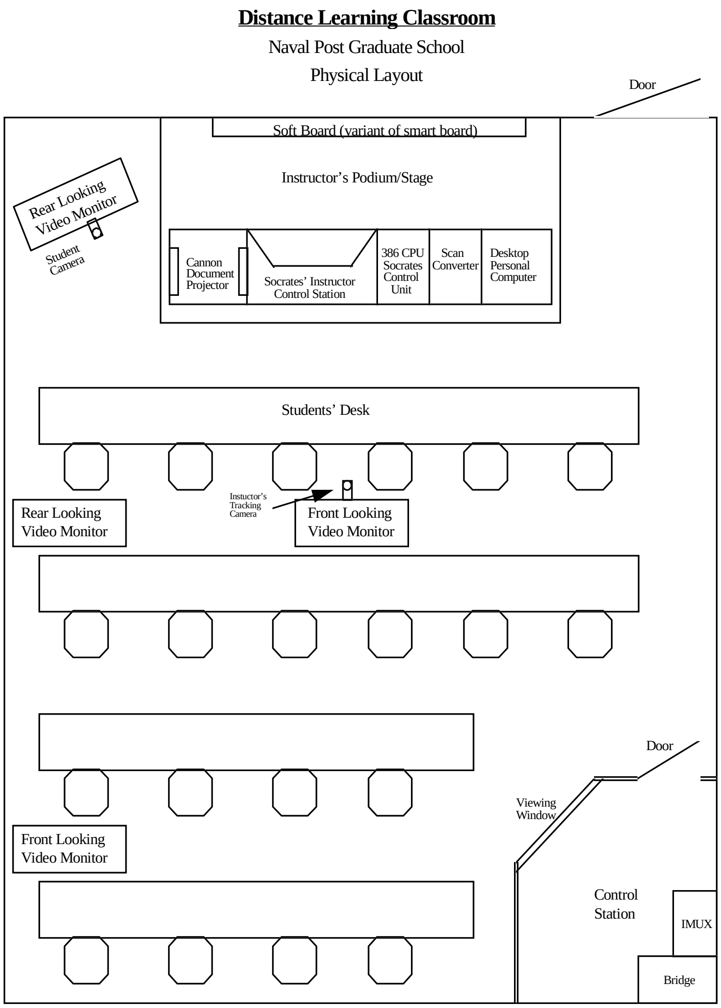
5 Investment costs, return on investment, and mods to current environment.

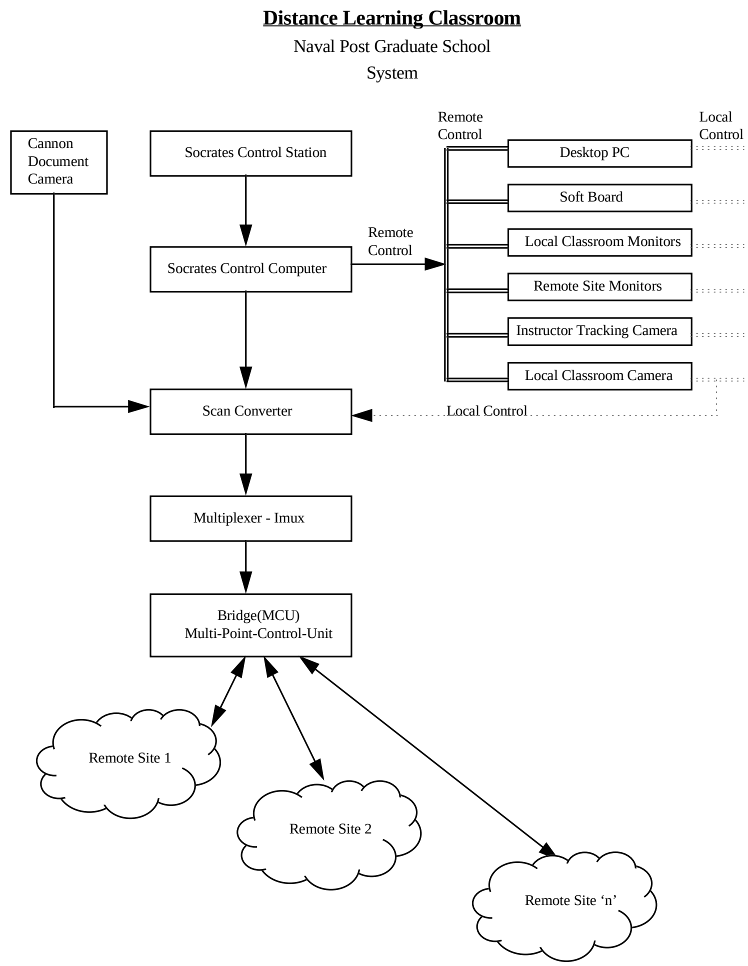
a. Teleconferencing facility. Every institution tailors their teleconferencing technology to fit their specific needs. We have selected NPGS as a teleconferencing facility to baseline for this report. This facility uses land line (ISDN), not a satellite, for delivery of the distance learning product. The facility consists of two rooms. They have been in use since 1994 and have developed real time, two way, multi-point (8 remote sites) wide area applications. Three people administer the system. The Manager is a GS 13 used 20% for leadership, organizational, and audio visual issues. The technical Audio Visual Expert is a GS 11. His time is divided into 1/3 for classroom support and 2/3 for smart classroom designs. The administrative Audio Visual Expert is a GS 9. He works full time for instructor training, classroom setup, and equipment operation during the actual class. Distance learning pays for itself. NPGS charges each customer approximately $22,000 to teach a new course at a remote site. NPGS customers include NavAir, NRAD, AFWIC, Moffet, Wright Patterson, PAX River, and China Lake. A typical distance learning/teleconferencing classroom can seat 20-25 students. NPGS's initial investment for both rooms was $500,000. An initial high capital investment is expected to lead to a lower cost of usage per incremental student than the current teaching/learning paradigm.

A satellite delivery system is also capable of providing distance learning to a teleconferencing facility equipped to receive a satellite signal and to distribute it . For this report we selected National Technical University (NTU). NTU broadcasts programs for various universities (i.e.Texas A&M) across the country. NTU transmits on a Telstar 401 satellite from their NTU Satellite Network

Satellite Costs	
Ku Band Antenna	$2,150
NTU Subsciber Unit	$8,950
LNB Downconverter	$ 150
Roof Mount	$1,050
Installation(4 days)	$ 800
Total	$ 13,100

Control Center. It uses compressed digital video. The basic components needed to receive the NTU signal include a Ku-band satellite antenna, NTU digital receiver/decoder subscriber unit (NSU), and a phase-stable low noise block (LNB) downconverter. The antenna selected allows receive only with the ability to receive broadcasts from four sites simultaneously. This solution has limited use since it cannot be used for two way interactive distance learning possible with the land line solution. Since this solution is receive only, a classroom such as that at NPGS is not necessary. Tuition fees for credit courses are comparable to those charged by state universities. Fees for short courses vary, depending on the source and the number of participants.





b. Broadcast television. The Educational Resources Center (ERC) has the capability to distribute video, taped or television, over 35 channels of coaxial cable. The system is old and its condition is questionable. Distribution within Bancroft Hall is limited to selected locations. Distribution to the desktop is not possible. The cost to replace the ERC television distribution cable plant and expand its distribution through all rooms in Bancroft Hall is cost prohibitive. NADN has the capability, when developed, to transmit 12 channels over fiber. NADN is better alternative for total use throughout the institution including to the desktop. Its development is estimated to be approximately $150,000 and is recommended for future use.

c. Courseware and WWW development. This is a software engineering effort and includes such concepts as Intelligent Tutoring, development of the Web, and use of multimedia to teach and learn. Hardware and software is relatively inexpensive when compared to development costs. Most serious schools have instructional development and media specialists who assist faculty in developing Web applications, multimedia courseware, and other IT products such as visualization and graphics. For technology environments such as teleconferencing facilities at least one technical person is available to operate the control room. Faculty must be involved in the development of products they will use. Development costs can be high. Just as an example, a team of 5 people working on courseware during the summer could easily cost $60,000. The only other additional cost would be software such as an authoring tool. A typical software license for five people is $3,000. Most staff productivity hardware (i.e. microcomputers, workstations, scanners, projectors, network) is readily available.

Labor Costs for Courseware Development

Position	Rank Step	Annual Salary	Loaded Hr Rate
Media Specialist	GS 9/5	35,904	20.82
Media Specialist	GS11/5	43,442	25.19
Assist Professor	Step 15	45,939	31.87
Assoc Professor	Step 25	57,484	39.88
Full Professor	Step 50	91,535	63.51
Total			$181.27

8 weeks x 40hrs/week x $181.27 = $58,006.40

d. Visualization. Visualization is extremely valuable to learning. Visualization is associated with animation, modeling, and graphics. To visualize data in its graphic format or as a three dimensional physical object adds another dimension to education and allows the serious student to analyze and interpret data. The SGI workstation supports visualization better than other workstations. Visualization in the classroom and laboratory would require upgrade and replace of existing SGI systems at a cost of approximately $650,000.

e. Virtual reality. The infrastructure to support simple ‘virtual environments’ will be available at USNA within 1.5 years. Virtual access to laboratories, classrooms, the Library from any other space such as a midshipman’s room will add tremendous productivity to faculty, staff, and students. Modification of NADN to a reconfigured scalable ATM network with unlimited Virtual local area network (VLAN) capability is a necessary next step and is in progress. Going to the next step and continuing to develop configurable and programable virtual reality spaces such as Iowa State’s Center for Emerging Technologies would be cost prohibitive in today’s budget climate.

D. Computer Course

1. Why should we train or teach midshipmen information technology? There are many compelling arguments why midshipmen should be taught and continuously improve their computer skills. One is to teach midshipmen basic IT skills necessary to challenge their own abilities and profit from an education which emphasizes the use of sophisticated technology. The other is to acquire a different set of skills necessary to manage, use, and continuously learn about rapidly changing technology in the fleet. Although this has been argued repeatedly, the following evidence illustrates the importance of information technology to the warrior and encourages the Naval Academy to teach "something" about the subject of "information technology":

a. In March 1992 OP945 completed a Naval Officer Computer Utilization Study. The study concluded that 88% of all officers through O-6 were required to use computers and that literacy beyond the level of word processing will become an entry level skill for all naval officers.

b. In 1995 the Navy realized a need to develop an enlisted rating with information technology skills. As a first step N7 announced the merger of the RM and DP ratings into RM21 (RM of the 21st Century). By March 1996 RM21 career progression and training support requirements were established. They include: new ‘A’ school graduates receive apprentice training necessary to work in a PC/Network/Digital world; all RM’s and DP’s, E7 and below, already in the fleet must complete a 40 hour computer based training (CBT) mandatory course; creation of a new journeyman "Information Systems Administrator" (ISA) course for all navy applications to provide skills necessary to operate and manage LANS with both DOS and UNIX technology; creation of a "Network Security and Vulnerability Technician" (NSVT) course to teach systems administrators network security; and creation of a masters level advanced communications systems supervisor course (RM21 capstone course) to provide skills necessary to manage large, multi-level, complex networks with wide area connectivity.

c. In February 1997 Vadm Cebrowski Director, Space Information Warfare, Command and Control (N6) gave a technical briefing open to the public. He asked and answered the following questions:

(1) What skill sets will be required of the new Information Warrior ?
(2) Will C4ISR impact future force structure requirements?
(3) How about weapons systems procurements ?
(4) How does "Sensor to Shooter" play?
(5) What impact is IT having on "Point-of-Spear" operations?
(6) Are we ready to fight Joint? What about Coalition Warfare?
(7) What are the threats to increased IT dependence?
(8) How should industry help facilitate the IT revolution?

d. In March 1997 CINCLANTFLT provided information technology guidance for the 21st Century (IT21) addressing implementation of standards for information systems on fleet units/bases. IT21 is a fleet driven priority to accelerate the transition to a microcomputer based tactical warfighting network. Implementation requires that all non-standard network operating systems (NOS) and e-mail products be replaced no later than Dec 99. These standards are focused on fleet tactical and secure messaging requirements. They emphasize 32 bit operating systems, high resolution displays, mass storage, and ATM backbones.

e. Both Middle States and ABET accreditation visits encouraged integration of further information technology into the curriculum. The Middle States Visiting Committee stated that the Naval Academy does not have systematic computer education for midshipmen and that the result was a graduate who has little experience or expertise in using the computer as a tool. The Middle States Association recommended, in its final report, that the Naval Academy should teach information literacy, or information access skills, in an electronic classroom setting to all midshipmen.

f. What do Midshipmen think? In April 1997 Midshipman Peter Sheehy, a 1/C English Major, submitted a paper for his HE 334 Professional Writing Course. The assignment was to write a paper which met the requirements of Naval Institute’s Arleigh Burke Essay Contest. His instructor was LTC Barton, Director of the Writing Center. The subject was computer training. Midshipman Sheehy presents a strong argument that despite the vast computer resources at USNA, the Academy has yet to introduce a formalized brigade wide computer education or training program to improve opportunities for education at the Naval Academy and to better prepare them for the fleet. It is suggested that readers of this report also read Midn Sheehy’s complete essay.

g. The Navy publishes a professional computing trade magazine called "Chips". It is published quarterly and sponsored by N6. This magazine illustrates the importance and use of information technology throughout.

h. One of the Navy’s ongoing efforts to integrate information technology is the Smart Ship Program. The charter specifically addresses applying technology to reduce both crew size and crew workload. One Pacific surface force ship and Atlantic surface force ship have been selected to pilot this project.

i. There is currently no course in the fleet designed specifically to teach junior officers digital information technology.

2. The basic entry level computer course for all midshipmen.

a. Background. In March 1996 the Superintendent tasked the Academic Dean and Provost to address teaching midshipmen computer skills. The Academic Dean proposed an ACTRAMID Computer Course similar to the current SI 250 course taught by Computer Science. The Computer Science Department suggested teaching a similar course during the academic year. Instead of the concentrated offering during ACTRAMID, the Computer Science Department course would be taught regularly throughout the semester. Originally the ACTRAMID course was going to be prototyped during the summer of 1996. Due to time and logistics this was canceled.

The requirement to teach an entry level computing course for midshipmen was introduced again as a task to be addressed by this ad-hoc Teaching and Learning Technologies’ Committee. A lingering question that continued to be asked was "Why do we need to the course?" and "Who do we teach?" To address the questions, the Institutional Research Board submitted a Statement of Work (SOW) soliciting interested faculty to apply for research funding to develop an instrument to assess the computer skills of incoming plebes, identify USNA academic computing requirements, and to identify computing requirements of the Naval Service. The due date for responses is 1 Jun. The prototype instrument delivery milestone is 1 August for use with the Class of 2001.

b. Course(s). It is recommended that two courses be taught. One is taught to plebes during plebe year. This course will provide them basics for plebe year and will also posture them to begin their major as a 3/C midshipmen. The second course is taught during either the 2/C or 1/C year. The objective is for each midshipman to graduate with the skills and knowledge provided below.

(1) Plebe Course. The plebe course is a non-credit course, taught one hour per week for 14 weeks. Plebes will be taught a hands on computer course in a computer lab. The course will be modularized. Each module will be testable and can be validated. Midshipmen who validate a module will not be required to attend that module's training. An overview of the subject matter taught follows:

- Working knowledge and relationship of computer components and peripherals.
- Basic knowledge of a graphical operating system.
- Basic knowledge of a word processing software package.
- Basic knowledge of a spread sheet software package.
- Ability to use electronic mail (e-mail).
- Ability to access a LAN and the Internet.
- Basic knowledge of computer ethics and intellectual property rights.

(2) Senior Course. There are three alternative approaches for teaching these skills: teach the course during the summer in an ACTRAMID format; teach the course during the academic year similar to the recommended plebe format; or teach the subject matter as segments of various courses in the core curriculum. An overview of the subject matter taught follows:

- Working knowledge of the Navy standard operating system.
- Working knowledge of the Navy standard software systems.
- Working knowledge of the Navy standard e-mail system.
- Ability to install and upgrade software.
- Ability to install and upgrade hardware.
- Ability to maintain a secure microcomputer.
- Ability to reconfigure a microcomputer.
- Ability to attach and access an ATM backbone LAN-FTP.
- Ability to use the computer logically to solve a problem.
- Basic knowledge of computer ethics and intellectual property rights.

E. Configuration Control for Academic Renovation. Information Technology Services Division has a chartered Configuration Control Board (CCB). The CCB will satisfy this requirement. The board meets weekly to review the management and control of software, hardware, and networking configuration and integration requirements in accordance with IT policy and standards.

The requirement is to provide configuration guidance for all academic spaces as each academic building goes through its renovation cycle and is finally brought back on-line. Academic spaces include classrooms, laboratories and display rooms, conference rooms and departmental libraries, lecture halls, productivity rooms, and offices. Although all of these spaces are important, the center of attention is the classroom and laboratory. The actual design of the classroom will be dependent upon the teaching methodology. The methodology will dictate which technologies populate the design. Since everything is teaching methodology dependent, and teaching methods change from faculty to faculty, and from course to course, the CCB will concentrate on guidance for building infrastructure which can support multiple designs and a variety of equipment. Infrastructure will include such items as power and data outlets, conduit (size, quantity, media population, etc.), lighting, power, ventilation, raised flooring, etc.

We intend to capitalize on experiences from other universities who have had similar experiences by using the services of Dr. Daniel Niemeyer. He will provide a consultation visit on 5 June to begin the process. His agenda will include the following: discussion of issues and goals; visit to classrooms in Sampson, Michelson, Rickover, Nimitz; meeting on Academic Renovation; visit ERC and Media Center; and meeting with the Gold Committee. Currently Dr. Niemeyer is the coordinator for classroom design at the University of Colorado, and has been responsible for construction and renovation of seventy campus classrooms. He provided consultations at more than fifty colleges and universities which gives him a national perspective on classroom technology. Additionally, as a faculty member, he understands the necessity for a user-friendly, technology classrooms. Appendix E includes Dr. Niemeyer's resume, papers from his Web site on media equipped classrooms, and national organizational resources which can contribute to our academic renovation efforts.

A second source is Mr. Doug Picard of International Automation Associates (IAA). He will also visit on 5 June. His expertise is focused on networking infrastructure, electronic classrooms, and teleconferencing.

III. Conclusions

A. Other Colleges and Universities. Computer based information technology profoundly affects the quality of education and the students' learning ability. Colleges and universities heavily invest in automating their campuses with a variety of proven basic shared technologies. Primary infrastructure technologies include high speed data networks and variety of electronic classrooms. Courseware immediately affects teaching and learning. Courseware, available for every subject, provides the most gain for the least cost. In the classrooms and laboratories, students are most receptive to products which emphasize graphics, simulation, animation, and visualization. Exotic applications are expensive and entertaining with small marginal educational value. Corporate sponsors and foundations, not institutions, fund most initiatives. Video teleconferencing, the newest technology, provides institutions an opportunity to offer education to resident students at remote sites and conferencing for on-site students and faculty. The most serious drawback to development and integration remains the institutions' failure to recognize courseware development initiatives as criteria for promotion and tenure.

B. U.S. Naval Academy. The Naval Academy is very competitive among peer institutions with respect to use of primary technologies. As with other universities, success comes from use of carefully selected courseware. Software and desktop computing hardware are exemplary. Faculty develop applications around specialized classroom and laboratory equipment instead of midshipmen microcomputers. This limits academic use of microcomputers midshipmen purchased upon entering the Naval Academy. NADN is the principal data network used by both faculty and students. With low shared bandwidth and serial architecture, NADN has limited value as an academic tool. Individual local area networks in academic departments are excellent.

C. Technology Costs. Using information technology to teach and learn must be thoroughly explored and its associated costs completely understood. Using technology to satisfy mission essential requirements is time sensitive and expensive, and has a totally different cost than using technology in a non-urgent setting. Reliability, security, and immediate corrective maintenance become issues. Continuous changes in academic requirements will require modifications to technologies. Data management will become critical and time consuming. All of this can negatively impact confidence in technology. Developing technology is a delicate business and must be balanced against other institutional requirements.

D. Expectation. Students will arrive as plebes expecting technology to be embedded throughout the institution and used in the curriculum. They will begin using technology as early as the first grade and come to the Naval Academy with advanced power user skills. An example is St. Mary's Elementary and High Schools. The elementary school recently completed its Middle States Association Accreditation. The school's project was 'Integrating Computer Technology into an Elementary School'.

IV. Recommendations. Recommendations must be achievable, affordable, and mission oriented.

A. Midshipman Computing Skills. Provide midshipmen with computing skills necessary to enhance their educational experience. This should be completed in a formal class setting prior to the beginning their major.

B. Midshipmen Microcomputers and use of Desktop Technology. Emphasize classroom and laboratory courseware development for standard desktop microcomputers in lieu of workstations to take advantage of the midshipmen's use of their microcomputers. Require midshipmen to use their microcomputer at every opportunity.

C. Infrastructure and Standardization. Develop an institutional infrastructure plan which treats networking as a utility. The data communications and telecommunications cable plants should have its own infrastructure much the same way as water, steam, and electricity. Network access, modification, and upgrade should be available on demand, routine, and inexpensive. Consolidate USNA and NADN networks and establish two domains, '.edu' and '.mil'. Migrate NADN to a faster ATM protocol. Plan the migration of non-standard academic environments to the institutional standard. This includes local area networking, file servers, and general administrative software. This will be a major improvement to the Naval Academy's teaching and learning environment.

D. Teaching and learning technologies best suited for midshipmen use. Develop a plan to prototype, develop, implement, or improve technologies best suited for midshipmen.

1. Develop a distance learning facility to receive both satellite and land-line delivery. The facility should be located in Luce Hall and/or in the Educational Resource Center's (ERC) studio.

2. Engage the faculty in courseware and Web application development. Begin in the summer. Plan the first summer institutionally. Target courseware development for each division. Emphasize faculty development through technology transfer by teaming media staff and skilled faculty with novice faculty. Provide dedicated funding for summer hire. Give promotion and tenure credit for completed products actually used in the classroom. Hold a technology fair prior to the beginning of the academic year to demonstrate courseware development.

3. Collaborate with other institutions to develop electronic mentoring and tutoring applications for use in the Academic Center. Conduct a market analysis to determine available software and consult with commercial (Sylvan) and educational (University of Pittsburgh) professional teaching and learning centers.

4. Investigate the use of virtual labs to replace existing labs, especially in those engineering and science departments whose labs will be affected for lengthy periods during the academic renovation. Two in particular are Electrical Engineering and Chemistry.

E. Interdisciplinary Initiatives. Encourage interdisciplinary collaborative efforts among departments. This achieves economies such as sharing facilities, contributes to developing faculty skills, and optimizes the use of technology. An example is the collaboration of Political Science, the Library, and Information Technology Services to develop two fully automated bibliographic instruction rooms and integrate into the curriculum.

F. ERC. Review ERC's contract. Redefine how ERC can best support the Naval Academy. Evaluate their effectiveness in supporting teaching and learning. As a minimum ensure ERC is capable of providing support for electronic classrooms, faculty development skills, and video teleconferencing. Develop NADN's video channel capability to support ERCs broadcast television requirement.

Appendix A

Charter

Teaching and Learning Technologies

1. **Purpose.** The purpose of this charter is to establish a committee of faculty and staff to investigate technologies available to teach and learn, and to recommend how these technologies can be used to support the Naval Academy's mission.

2. **Organization**. The five person committee will be chaired by the Deputy for Information Technology, Mr. Louis Giannotti. Four additional committee members will consist of three faculty, one from each academic division, selected by the Academic Dean and Provost, and one member selected by the Director of Professional Development.

3. **Background**. If used properly, information technology can provide a significant improvement in the quality of education and training. Developments in broad bandwidth networking, authoring tools for multimedia, 4th and 5th generation software products, and reliable systems provide technology applications used by instructors to teach and by students to learn. The Naval Academy has a well developed and mature computing environment capable of introducing teaching and learning technology concepts in classrooms, laboratories, and Bancroft Hall. With our emphasis on attracting gender, ethnic, and racially diverse midshipmen, we accept very capable students with a variety of academic experiences and interests. Some have had academic opportunities never encountered by others, resulting in a range of academic skills at different stages of development. We must posture ourselves by leveraging technology to improve basic skills such that academic programs can provide the excellence that will challenge every student and improve their potential for success.

4. **Tasking**.

A. Define teaching, training, and learning technologies. Identify available legacy, prototype, and migration technologies, and present profiles of ongoing developmental projects at other institutions.

B. Describe the Naval Academy's complete information technology environment, and in the context of above, present teaching and learning technology efforts ongoing at the Naval Academy, NAPS, and the Naval Station.

C. Identify teaching and learning technologies best suited for faculty and midshipmen use. Discuss how selected technologies can be used to teach and learn. Explain methods for developing, integrating, and implementing these technologies. Present resources available and potential obstacles to be overcome. Include investment costs, return on investment, and recommended modifications to the current environment,

D. Demonstrate teaching and learning technologies.

E. Offer final recommendations with a forecast of potential benefits.

F. Report to the Superintendent through the Executive Steering Committee.

5. **Calendar.**

A.	Present charter to ESC	Dec 96
B.	Select committee members	Jan 97
C.	Draft report	Mar 97
D.	Brief ESC	Apr 97
E.	Present final report to ESC	May 97

Appendix B

Impact of Technology on Learning Effectiveness

Kim Astrid Reid
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One of the key questions associated with educational technology is whether or not the technology actually contributes to student learning. Since the first uses of educational radio and television, hundreds of studies have tried to assess the instructional effectiveness of new technologies marketed to schools. Because so many of these studies are similar in design, it is possible to group them into major categories of research. Our understanding of educational technology's effectiveness has evolved with the outcomes of studies which have focused on mode of instruction, media attributes, context of learning and distance learning success factors.(1,2) Learning effectiveness, in these studies, has most often been defined in terms of traditional measures of student achievement, for example, test scores and final grades.

Two common approaches to research on specific media have been used. The first type has addressed comparisons of new media with "traditional" classrooms. In these studies, distance education was compared numerous teaching methods used in the traditional classroom, including lectures and class discussion. (3,4) Many studies have concluded that no significant differences in achievement emerge as a result of such comparisons. (5,6,7,8,9,10) That is, student achievement is not a function of the mode of instruction. However, a few studies have shown that mode of instruction is a factor in achievement. These studies have found slightly higher achievement levels when interactive computer programs (including e-mail), one- and two-way video, and audio media, were utilized. (11,12)

The second approach has explored the unique features of each technology medium and its connection to particular skills or abilities. These "media attributes" studies have, for example, looked at television's ability to enhance the learner's visual learning. Most of this research has focused on how the unique features of particular technology (television, audio media, videodisk, interactive computer programs and other technologies) contribute to students' learning. They have suggested positive gains in student learning in a variety of subject areas. (13,14) For example one study showed that a telecourse had a positive impact on students attitudes, and in turn, learning of economics. (15)

Other research has focused on the context of the learning rather than specific modes of delivery. These studies concentrated not on the technology itself, but on how technology fit with all of the other aspects of the classroom with which students must contend. Such studies examined factors that could affect the individual learner, including the design of the lesson, peer interaction, and learning style. Several of these "contextual studies" examined relationships among multiple factors in the classroom. These studies showed positive gains in student learning when combinations of teaching media and various methods of instruction were linked. These studies often looked at collaborative teaching methods in conjunction with the use of technology. For example, students using computer conferencing technology to evaluate each other's work or work in teams on larger projects was studied. The interaction of collaborative work and technology often produced positive results in student achievement. (16)

Finally, some studies have identified several factors that seem particularly important in distance learning situations. High levels of student motivation, a strong work ethic, and intensive student support measures often resulted in success for learners in distant classrooms. (17,18,19,20,21) Student support has been defined to include not only academic services, but also the identification of students' needs and problems, the provision of opportunities for interaction with peers and teachers, and the ability to maintain motivation. The most important factor for achieving success in distance learning has been the degree to which teachers and support staff are able, by providing structured activities that utilize technology well, to encourage students to undertake responsibility for their own learning.

In summary, a range of studies about technology's impact on learning effectiveness have demonstrated positive results when educational technology is employed. Much of this research has focused on specific features or contexts of educational technology use, providing rich information to those interested in the effective use of technology about specific factors which have contributed to learning success.

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Using Information Technology to Enhance Academic Productivity

By
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Introduction

Across American higher education the lure of the new information technologies remains as uncertain as it is unsettling. While few doubt that information technology (IT) has the potential to enhance teaching and learning, there is no agreement on how that technology should be used to boost academic productivity--or whether such an increase is in itself a valid goal if its enhancement means substituting technology for the more traditional, labor intensive rhythms of higher education.

Not that innovation is lacking on the micro scale. Examples of new technology applications abound. Most institutions have made major investments in the new technologies, distributing computing capacity across their campuses, linking faculty with students as well as with one another, and generally providing the necessary IT infrastructure that is a precondition to faculty involvement. What is missing, however, is any overarching sense of purpose along with any practical sense of what the shape and consequences of successful innovations might look like. Missing, as well, is any sense of urgency--either that which should accompany the optimism of the true-believer or that which should derive from the realization that in someone else's hands information technology threatens higher education's historic monopoly over the certification of students.

It was this set of issues that occasioned a conversation between the two of us, with our backgrounds in academic restructuring, and Educom, a pioneer in facilitating IT applications and organizer of the recently launched National Learning Infrastructure Initiative (NLII). Educom asked us to think about how the infusion of information technology into the educational process can reverse the declining productivity of American higher education. Eventually, our conversation grew to include an eighteen-member roundtable, which Educom convened in June 1995, consisting of higher education administrators, policy analysts, faculty members, and independent information technology consultants. Meeting at Wingspread under the auspices of the Johnson Foundation, this roundtable helped us test an initial statement of the issues, contributed its own sense of what was possible and not possible, and led us in the end to recast both our definitions of academic productivity and the role information technology might play in its enhancement.

We begin with a pair of observations.

First, the demand for IT-based teaching and learning programs will grow substantially, probably exponentially, over the next decade. In an economy that is itself increasingly knowledge-based, the new information technologies offer an economical means of providing the continuous education the U.S. now requires as well as a more readily accessible form of post-secondary education and credentialing.

Second, IT will change teaching and learning profoundly, no matter what the response of traditional higher education institutions. Just as the development of the printing press forever changed the teaching enterprise, IT represents a fundamental change in the basic technology of teaching and learning. The transformation will take a long time, long enough for critics to claim that perhaps higher education can thrive without fundamentally changing itself in response to the new technology. If traditional colleges and universities do not exploit the new technologies, other nontraditional providers of education will be quick to do so.

In short, we started with the view that IT offers great potential but in order to reap the benefits, institutions will have to transform themselves in fundamental ways. Our task is to understand these changes in terms that are both practical and operational. We begin by surveying the advantages and disadvantages of IT in the teaching and learning process. Then we consider the barriers, both internal and external, that traditional higher education institutions face in transforming themselves to take full advantage of the new information technologies. Next we examine more carefully the options for improving academic productivity and how the successful adoption of IT-based programs may be expected to affect the balance of technology and human capital within colleges and universities. We conclude this paper with a consideration of two alternative adoption scenarios and their implications for the future of higher education. While some of our predictions may seem grim, we believe that both scenarios are plausible and that the outcome will depend on whether institutions step up to the challenges spawned by the revolution in information technology.

More important, the scenarios themselves shed important light on the two questions whose answers both divided the roundtable and, not so coincidentally, reflect the difficulties that higher education is having in adopting IT- based teaching and learning strategies. First, can or should information technology actually supplant rather than primarily augment the traditional means of delivering a post-secondary education--in other words, is something essential compromised by substituting IT-based programs for traditional teaching methods? Second, how is higher education going to pay for the acquisition of the new information technologies? Will IT-based teaching and learning strategies, because they tap new markets and yield improved quality, yield sufficient growth to finance to acquisition of the necessary technology as an add-on? Or will the necessary investment in IT-based strategies require the same substitution of technology for labor that has characterized the transformation of other enterprises in search of increased productivity?

It's Potential

Most discussions of the possible advantages of IT-based teaching and learning strategies begin with a weighing of the relative advantage of technology against the inherent capabilities of faculty. What can IT contribute to increasing learning productivity? Here two general propositions, based on previous work but reinforced by discussion at the roundtable, that offer a natural starting point.

1. IT offers economies of scale: After a (sometimes large) front- end investment, the cost of usage per incremental student is apt to be low. Moreover, access to very large amounts of information can be obtained at low incremental cost.

2. IT offers mass customization: Technology allows faculty to accommodate individual differences in student goals, learning styles, and abilities, while providing improved convenience for both students and faculty on an "any time, any place" basis.

These propositions add up to a "modern industrial revolution." The first suggests a departure from the traditional handicraft mode of education, where faculty learning curves (for the production of learning) are shallow and capital offers little leverage beyond the traditional physical plant. But whereas the original industrial revolution led to undifferentiated mass-produced outputs, the modern information-driven revolution permits production to be adapted to the needs of each customer. The resulting advantages are profound, as we shall see. But we must weigh the benefits of departing from the handicraft educational paradigm against the costs of change--and the possibility that the result may not be recognizable as "higher education" as it has traditionally been conceived.

Perhaps IT's most widely known potential, through such tools as the Internet and the various online databases, is access to enormous quantities of information. As systems become increasingly sophisticated, IT will provide a growing capacity to navigate among such information resources at low cost. In the future, students will be able to access Library of Congress holdings online or view paintings in any museum in the world. In the past, libraries held the keys to research and knowledge; in the future, networked desktops will allow much of the same access when and where the user desires it. What is at stake is not just the library's sense of "place," but more importantly its sense of control. When "dialing up" becomes the normal means of accessing of information or learning about assignments rather than "going to the library," the result is a diminution of the institution's ability to limit access to a specific time at a specified address.

More generally, IT eases the limits of time and space for education activities. A state with an extensive distance learning program reports that many faculty have discovered that good communication between teachers and students remains important but direct physical contact is less so. IT will bring the best lecturers to students via multimedia anytime and anywhere so that, like the recordings of the country's most celebrated artists, those of the best will drive out those of the merely good. This sort of access is especially important for the increasing numbers of nontraditional students in higher education, who often have job or family responsibilities limiting their possible school hours.

Finally, IT enables self-paced learning with sensitivity to different learning styles and continuous assessment of student progress. The areas that can profit most from IT-based strategies are those subjects that have a high volume of students, a standardized curriculum, and over whose content faculty are less possessive. Examples of good target subjects include remedial and basic math, general education courses, and composition courses. IT enables students to work at their own pace with continuous assessment, in contrast to the traditional post-secondary education method, which can be described as batch- processing with episodic assessment. Continuous assessment allows teachers to pinpoint the areas where students falter--and in the case of some multimedia programs, those areas trigger further practice automatically so that students receive more instruction "just in time," when they need it most.

Because of its capacity to focus on individual assessment, IT will make the teaching and learning enterprise much more outcome-oriented, a change that has important implications for learning productivity. In fact, the areas that have made the most inroads with IT are subjects like foreign languages, math, and writing, whose outcomes can be most easily delineated. Continuous assessment provides the data needed to map the relation between cost and benefit, thus opening the way for experimentation and innovation.

Imagine, for example, the case for math remediation. If a group of community colleges, each spending substantial sums of money providing remedial programs in mathematics the old fashioned way, pooled the resources they would have spent on these classes and instead invested in the development of a good self-paced multimedia program, the savings after the first year could be substantial. We have been told that, "For an investment of $50 million, one could imagine solving a $200 million a year problem, and quality could be continuously improved." Not only could institutions invest less after the initial program is established, but also some costs could be passed along to the students in terms of a modest payment for software rather than textbooks. The potential barriers to this sort of effort, which we will discuss later, include bureaucratic and political ones for the institution, as well as motivational ones for the student. Often the students who would most benefit from self-paced learning have the least motivation to do so. However, a scenario like this one strongly suggests that, given sufficient volume, IT could reduce the marginal cost of teaching additional students.

As this example suggests, IT has strong potential to increase learning productivity in the areas of codified knowledge and algorithmic skills. In these specific areas, the implication is that IT should supplement human instructors whenever possible--human intervention should be oriented mainly towards making the advantages of IT accessible to all learners. In the case of math remediation, that might mean monitoring student motivation and providing support at critical junctures to ensure that a student completes the program. Wherever a significant portion of a curriculum includes non-codified, non-algorithmic knowledge, however, faculty maintain their historic advantage. IT provides a strong element of synthetic experience, of virtual reality fine for some purposes but not all.

In general, however, IT will empower students to have greater control over the learning process, with all the benefits associated with active learning and personal responsibility. Not only will students decide when to learn and how to learn, increasingly they will also decide what to learn and how that learning is to be certified. It is in this sense that IT "unbundles the learning enterprise from the teaching enterprise." Traditionally, higher education institutions have combined several functions in their faculty. Faculty are architects as they design learning programs; navigators as they help advise students in their course of study; instructors when they lecture; mentors when they help students form a sense of connectedness to the world; and evaluators and certifiers as they decide to grant students grades or degrees.

IT will allow educational providers to separate some key functions traditionally bundled together. For example, not all faculty will be architects and instructors once the best lecturers become available across campus boundaries--but perhaps more faculty will be involved in navigating, mentoring, and certifying. The investments in knowledge codification, delivery systems, and assessment techniques will decouple the provision of learning from the certification of mastery, thus opening new modes of educational delivery and paving the way for new entrants to the higher education marketplace.

These separations will allow colleges, universities, and other educational providers to unbundle their offerings and prices. Students will be able to pay for instruction with little mentoring or, alternatively, much mentoring, as they choose. They will be able to get learning with certification or contract for learning and certification separately. Both innovations will improve higher education's overall productivity, and they also will undermine the monopoly now enjoyed by traditional providers. One must remember not to confuse "contact" with "contact hours": some students will continue to want a traditional collegiate education with all its socialization or "contact" while others will just want the certification, the "contact [or credit] hours." IT will allow this separation and--moreover--allow the learner to choose either or both. IT's strongest potential influence is that it will place the advantage with the learner rather than the institution, by creating a more effective market in learning as opposed to a controlled allocation of scarce teaching resources.

Some fields are not suited to extensive computer mediation, especially those concerned with questions of meaning and value, of culture and philosophy. Nor, even beyond those subjects, will IT-based teaching and learning programs ever substitute fully for human interaction. The most IT can do is extend or enrich the scope of human interchange, as in distance learning or where communication is mediated through computers. What institutions will have to judge in the future is how and where that human interaction can be most effectively employed.

Barriers to Adoption

Beyond these innate limitations of IT, a host of barriers, stemming principally from the conservative tendencies of colleges and universities themselves, inhibit the full-scale adoption of IT-based strategies in traditional institutions. We describe these tendencies in "Expanding Perimeters, Melting Cores, and Sticky Functions: Toward an Understanding of Current Predicaments," where we argue that much of higher education remains characterized by its commitment to constancy, to a "sense of sustaining mission" and "a belief that at its core the academy is largely immutable--its costs largely fixed, its purposes well established, its educational and intellectual values well honed."

1. We shall refer to these constants as "traditional academic values."

Foremost among the barriers to IT's full adoption is a set of established institutional norms relating to teaching methods, faculty autonomy, and notions of productivity. The set of teaching-method-norms include such considerations as teaching loads, student-teacher ratios, and class sizes. Optimizing the use of information technology requires faculty to change what they clearly prefer to leave untouched. The very interconnectivity of the new information technologies similarly challenges the faculty's definitions of autonomy, which dictate that a professor can individually decide what, when, and where he or she teaches. Finally, faculty will have little interest in IT's capacities to boost academic productivity to the extent that they lack an appropriate vision of learning productivity.

2. Most faculty think of productivity in terms of scholarship, especially research, and in terms of teaching tasks rather than learning accomplishments. Teaching is usually viewed as scholarship-related" without the "fitness-for-use" (in terms of student needs) criterion more appropriate for considerations of learning productivity. Without such considerations, the potential benefits of IT may seem neither apparent nor desirable.

Faculty have one other predilection that deters them from adopting IT: given the choice of additional money for information technology or another faculty member, most faculty would chose the additional faculty member-- and almost none would opt for additional expenditures on information technology if the result would be a smaller faculty. Like a brotherhood of monks, faculty intrinsically value other faculty members.

In our study of academic departments, we have found departmental characteristics and processes that also inhibit the adoption of IT. The paper by Massy, Wilger, and Colbeck, entitled "Hollowed Collegiality" describes three general characteristics that obstruct collective decision-making and change:

First, fragmented communication patterns isolate individual faculty members and prevent them from interacting around issues of undergraduate education. Second, tight resources limit opportunities and strain faculty relationships. Third, prevailing methods of evaluation and reward undermine attempts to create an environment more conducive to faculty interaction.

3. Although these three characteristics describe most departmental interactions, many departments still maintain a veneer of collegiality, the aforementioned "hollowed collegiality." The very lack of discussion that furthers civility and equity while maximizing faculty time has all but precluded serious consideration of strategies for increasing learning productivity.

In a large and growing number of institutions, incentives for teaching are few while those for research are significant. This fuels the "academic ratchet," a movement toward increased research production and reduced class loads.

4. Many departments pay little attention to their teaching and learning processes; research is carefully evaluated, but teaching and learning seldom are audited effectively. Although individual professors evaluate students in individual courses, the departmental curriculum as a whole often lacks explicit educational objectives or outcome and performance measures for those objectives. To be effective, IT-based teaching and learning programs require such measures; at the same time, the introduction of a new information technology raises the question of comparative cost. Since most departments have little knowledge about the amount they actually spend on specific learning and teaching activities, the cost trade-offs between IT-based strategies and traditional process elements are almost impossible for them to assess.

Productivity Enhancement

Economists define productivity as the ratio of outputs to inputs, or more generally as the ratio of benefits to costs. Productivity can be improved by:

1. Producing significantly greater benefits, encompassing quality and well as quantity, at modestly greater unit cost ("doing more with more")

2. Spending significantly less money while limiting benefits reductions to modest levels ("doing less with less")

3. Producing greater benefits while spending less money ("doing more with less")

Productivity also can be increased by improving quality at the same unit cost--a result we consider a limiting case of "doing more with less."

So far, most IT-based academic productivity improvements have involved doing more with more. With labor--especially faculty labor--considered to be fixed, IT becomes a quality-enhancing add-on. This fits the faculty culture but suffers from at least two serious deficiencies.

First, scarcity of add-on funding limits IT's rate of adoption. While colleges and universities might like to pour money into more-with-more productivity enhancement, most are not in a position to do so. Funding scarcity constrains the courseware market, thus inhibiting would-be developers from making the large front-end investments needed to exploit fully IT's potential advantages.

Second, and more fundamentally, the more-with-more approach does not address the academy's need for cost containment. One can imagine a scenario where widespread IT add-ons produce a situation like that found in medicine, where technological breakthroughs produce a spending race that eventually threatens the system's affordability. Tight financial circumstances currently inhibit such scenarios, but even if today's constraints could be relaxed, more-with-more productivity growth would eventually encounter new financial limits.

While higher education cannot limit itself to more-with-more productivity improvements, we certainly do not advocate doing less with less unless it becomes truly necessary. Corporate America has found that downsizing can generate productivity gains, but few campuses would wish for such trauma. Therefore, we will focus on situations where institutions retain the ability to choose when and where productivity gains will be sought. By retaining such discretion, institutions can achieve more with less where circumstances are propitious and then redeploy the money saved to achieve other institutional purposes.

Using IT for more-with-less productivity enhancement requires that technology replace some activities now being performed by faculty, teaching assistants, and support personnel. With labor accounting for seventy percent or more of current operating cost, there is simply no other way. Faculty will have to reengineer teaching and learning processes to substitute capital for labor on a selective basis. Failure to make such substitutions will return institutions to the more-with-more scenario--though one must also recognize that failure to substitute intelligently will undermine educational quality and thus negate productivity gains.

Intelligent substitution will require much more attention to the processes by which teaching and learning actually take place. Faculty will have to invest time and energy in learning about what they do and why they do it, and then open themselves to the possibility of doing things differently. Departments will have to understand teaching costs at the level of specific activities, not simply in broad functional terms. Activity-based costing becomes critical when one considers substituting one process element for another. Faculty may be able to judge technology's impact on quality, but such information cannot produce decisions without good data on relative cost.

The two of us have developed an activity-based costing model for departmental teaching processes.

5. The model encompasses teaching-related faculty time, support staff and teaching assistants, facilities, and, where applicable, information technology. Most of the data are available from

registrars, deans, and financial officers, and the remainder can be collected from focused telephone interviews with faculty (not time-utilization diaries). The study currently is in pilot testing with fieldwork planned for 1995-96.

We designed the model to produce benchmark data on conventional teaching methods. However, the methodology can readily be applied to natural experiments in which departments have substituted IT-based activities for labor- intensive ones. The model also can be used to structure "what if" scenarios, thought experiments in which alternative teaching and learning processes are imagined, judged for efficacy, and costed out. We believe that such experiments will lead to the development of new design principles for teaching and learning processes. These principles will replace the traditional rules of thumb. They will encourage a greater focus on continuous improvement and, where appropriate, reengineering to exploit fully the potential of information technology.

The Capital-labor Ratio

Using information technology to enhance productivity will increase the ratio of capital cost to labor cost in the academic budget, whether or not overall costs can be reduced. Larger capital-labor ratios represent a shift away from the handicraft mentality. They offer three major advantages.

First, real labor costs tend to rise with economy-wide productivity gains (say two percent per year, on average), whereas technology-based costs tend to decline due to learning-curve effects, scale economies in production, and continued innovation. Increasing technology's share of cost will reduce overall cost growth until the rate differential reduces technology's share to the point where labor again dominates. By this time, however, total cost will be lower than it would have been without the injection of technology. If the real cost of technology were to decline at a 25 percent annual rate, after ten years the alternative scenario would cost about 12 percent less than the baseline. If the rate of decline is only 10 percent, the saving ten years out would have passed 9 percent and still be rising. Given the differential growth rates of labor and technology, one can expect positive long-term returns on investment even when returns are negligible during the first few years.

Second, technology-based solutions also tend to be more scalable than labor-intensive ones. While our model does not address economies of scale, one should expect that additional students could be accommodated at lower cost with technology than with traditional teaching methods.

Finally, technology provides more flexibility than traditional teaching methods once one moves beyond minor changes that can be instituted by individual professors. The "career" of a workstation may well be less than five years, whereas that of a professor often exceeds 30 years. Workstations don't get tenure, and delegations are less likely to wait on the provost when particular equipment items are "laid off." The "retraining" of IT equipment (for example, reprogramming), while not inexpensive, is easier and more predictable than retraining a tenured professor. Within limits, departments will gain a larger zone of flexibility as the capital-labor ratio grows.

The benefits of shifting away from handicraft methods, coupled with scale economies and increased flexibility, argue for the adoption of IT even when one cannot demonstrate immediate cost advantages. For example, the ability to break even during the first few years provides strong justification for going ahead with an IT solution, provided the effects on quality are not harmful.

A Hypothetical Case

Imagining how the substitution of technology for human capital might work once the traditional constraints have been lifted is not difficult. We have begun to see evidence of such substitutions, but at this stage a hypothetical case is better than dealing with the complexities, caveats, and disclosure limitations of a real situation.

We imagine the teaching of introductory microeconomics at a liberal arts college: first, according to traditional methods, and then, using an IT- based process fashioned after Rensselaer Polytechnic Institute's successful studio physics, chemistry, and calculus courses.6 The traditional method requires 6 sections of 48 students each, taught by three faculty members twice a week, to accommodate an assumed 288 enrollments. The upper portion of Table 1 shows this configuration to require 180 contact hours during the academic term. We also assume that six undergraduate student preceptors are utilized, each at 12 hours per week.

Contact hours grossly underestimate the amount of time faculty actually spend in their teaching duties. Faculty spend time out of the class--before the term begins, during the term, and after classes end. Table 2 lists the activities pursued during the term, with data that might be obtained from faculty using the traditional teaching methods presented in the first column. According to the hypotheticals, each professor spends about 20 hours per week, in addition to his or her four contact hours, in course-related duties. An additional 30 hours is assumed to be spent on preparation before the term begins, and 38 hours in grading and follow-up after the end of classes. These figures do not include the faculty's indirect teaching effort--time spent keeping up with one's field, in major course revisions, and on scholarship. Costing out the included time commitments and adding allocations for the undergraduate preceptors and facilities utilization produces a total cost for the course of $71,396, or $248 per student, of which some 96 percent represents the cost of labor.

The lower portion of Table 1 presents our imagined configuration for "studio microeconomics," based on as-yet undeveloped courseware that mirrors the learning programs used by Jack Wilson and his colleagues at RPI for teaching the natural sciences and introductory calculus. First we replaced the standard format of 30 one-hour lectures per term by 7 two-hour studio sessions, where 48 students meet with the professor in a workstation-equipped classroom. Students are expected to learn independently to a substantial degree, using the studio, other computer labs, or their own machines. Voluntary studio sessions, which meet an hour each week under the guidance of a professor, assist students who are having difficulty, and undergraduate preceptors and faculty are available by e-mail as well as in the office. We have assumed that one-fourth of the students attend the voluntary sessions each week, though 50 percent more could be accommodated by increasing group size from two to three at the workstations.

One of IT's potential advantages is to free faculty-student contact time for discussing the implications of what the student has learned independently. Our configuration honors this principle by maintaining all but one of the weekly discussion sessions taught by faculty. Now, however, these sessions need not take codified-knowledge questions as first priority. Students have alternative means of getting their questions answered, so the discussions can focus on non-codified knowledge and deeper questions of meaning. We believe that using information technology in a scenario like this can enhance rather than curtail student-faculty time together--with attendant improvements in educational quality. Even greater advantages could be obtained by abandoning the traditional course structure altogether and adapting a mastery learning format. While we believe such an approach offers great potential, we did not try to simulate it because we wanted a straightforward cost comparison with the traditional course.

Relieving faculty of repetitive labor represents another of IT's advantages. Preparing a semester's worth of 50-minute lectures can be a time- consuming task, even when one has taught the material before. Because the courseware embodies significant structure, which would be improved continuously and cumulatively by the authors, faculty do not have to "reinvent the wheel" for each week's lectures. They can key off the courseware and the student questions that interaction with the courseware elicits, rather than putting the students into passive mode and carrying the main continuity burden themselves. For this reason we felt justified in reducing each professor's weekly preparation time from 6.5 to 3.5 hours as shown in the right-hand column of Table 2. Likewise, because the courseware takes over much of what used to be quiz and exam preparation and grading, we reduced the average weekly hours devoted to these tasks from 4.0 to 2.5. We also guess that better learning support and student-faculty in-class interaction will reduce the office-hour load from 5 to 2 hours, for a total out-of-class time of 11 hours per week.

Some new costs offset these gains. First, of course, comes the cost of the technology itself. This is built into the model by means of an allowance for depreciation and maintenance of special facilities, workstations, and software. Cost of operating central networks and servers are not included, but neither is the cost of library acquisitions and operations included in the conventional model. Looking to direct labor cost, we doubled the number of undergraduate preceptors to provide support for the students' independent learning. We also doubled support-staff time to 12 hours a week to allow for hardware and courseware setup, maintenance, and administration. We did eliminate the weekly hour of faculty supervisory time, however, believing that the higher level of course organization would bring this time under the weekly hour (per faculty member) allocated to collegial meetings. Lacking any specific rationale, we did not change the "before-term" or "after-term" faculty time estimates.

The new configuration produces essentially the same cost, $71,408, as the traditional configuration. However, the labor content now has dropped to 84 percent. Some $11,392 of capital-related cost has been injected into the teaching and learning production system, and paid for by labor-cost reductions. The result, we argue, is improved learning at the same cost as the baseline configuration. We do not rule out the possibility of improved quality at lower cost (as appears to have been achieved at RPI), but we did not wish to put forward such a result based on hypothetical data. As we shall see, even break-even cost substitution confers economic advantages because it increases the ratio of capital-based cost to labor cost.

The question remains: "What does an institution do with the faculty hours freed up by capital-labor substitution?" The saved hours might relieve shortages elsewhere in the institution, but this outcome becomes less likely if the institution's markets are not expanding. No financial saving accrues if the hours are simply redirected to departmental research as has been traditional in many institutions. To do so would simply speed up the academic ratchet, which would not meet higher education's economic needs or satisfy the enterprise's critics.

Absent demand growth, the scenario requires a net employment reduction for the institution taken as a whole. Faculty might take over duties now performed by staff, or regular faculty might displace auxiliary faculty, or the regular faculty may decrease in number. Absent sudden revenue setbacks, which would cause trouble in any case, the downsizings should generally be attainable by attrition--easier to achieve with staff and auxiliary faculty, but even among regular faculty there is some attrition nearly every year. About three percent of an institution's tenured faculty may be expected to turn over in an average year, with larger numbers expected during the next decade. Matching one of these three percentage points with one percent each from the auxiliary faculty and the relevant staff would produce a three percent overall annual employment reduction. Our scenario could be implemented in something like five years--quite an acceptable outcome if it could be accomplished.

Two Visions of the Future

Achieving even the modest substitutions envisioned in the previous section will be difficult for most colleges and universities. Achieving information technology's full potential, which would require far more extensive changes, could be problematic indeed. Concerns will be raised about educational quality, about the central importance of traditional means of instruction and established patterns of student choice. The issue that underlies these concerns, IT's true Gordian knot, is the trade-off between faculty control and educational cost.

Concern about costs has been one of the drivers of change in nonacademic organizations. In higher education, public criticism and calls by state agencies for increased institutional accountability have a strong cost component, an implied question about value-for-money. A small core of traditional institutions will probably remain buffered from these changes: these are the well-endowed institutions with many more applicants than student places. A small core of traditional learners, those who can afford it and those whose abilities are rewarded with scholarships, will continue to seek out the traditional handicraft-oriented education that has been the hallmark of our system. For these students, traditional education provides acculturation as well as learning. The public has begun to question, however, whether this model is extendible to the whole of higher education. Already the criticism of higher education's rising costs suggests that society finds this educational model too expensive for massified higher education.

Competition for the learner who does not desire such expensive, labor-intensive education already has increased. Sometimes this competition comes from within universities in the form of distance learning programs; often, the competitor is an outside organization. IT-based teaching and learning programs with built-in assessment protocols offer these other organizations a means to break the faculty monopoly on knowledge and certification. Given new competition and better performance measures, one can predict that the general level of educational quality will increase and that, subsequently, the cross-subsidies from teaching to research which currently exist in many institutions will come under fire. Given the tremendous knowledge base already extant in their communities, higher education institutions have a significant advantage in capturing this new market in learning--but only if they invest their resources wisely.

With this in mind, we have drawn up two alternative scenarios of investment in information technology, with different outcomes for the future of colleges and universities. The first is "business-as-usual," a scenario in which traditional higher education institutions, especially research universities, try to maintain their monopoly over the knowledge base. These institutions resist substituting capital for labor and instead try simply to add IT on to their existing operations. They retain the traditional courses, teaching configurations, and academic calendar, not altering much to accommodate the new possibilities opened up by information technology or to meet the needs and aspirations of new generations of learners.

In our earlier paper, "Expanding Perimeters, Melting Cores, and Sticky Functions: Towards an Understanding of Current Predicaments," we described the development of two economies within institutions over the past fifteen years.7 These economies consist of a "perimeter," those faculty who are acting entrepre-neurially, constantly expanding the scope of their activities though not necessarily holding to their traditional teaching mission, and a "core" which has rigidly stuck by its educational values and, in some cases, suffered severe revenue losses. If business-as-usual continues, the entrepreneurial activity around the perimeter will continue to expand; meanwhile, continuing financial pressure due to state funding limits and tuition resistance will increase pressure on the core, leading to an eventual "meltdown," defined as a loss of vibrancy, failure of faculty renewal, and diminished creativity and scholarship. Reductions of research funding can only compound the problem.

Business-as-Usual. In this non-adaptive scenario, other organizations will cherry-pick the knowledge base and intellectual property that colleges and universities have helped develop but have been unable to exploit in terms of revenues. We predict that the consequences of this scenario will vary over the different segments of higher education, namely that:

1. Research universities will lose out competitively to other higher education segments. Well-endowed highly selective institutions will do better than average, however.

2. Liberal arts institutions will be hard-pressed financially as the cost of labor continues to rise relative to the rate of inflation. The tuition pricing umbrella that the research universities have offered liberal arts institutions may diminish, forcing even greater financial constraint.

3. More innovative nontraditional providers will take over a greater share of the undergraduate education market. They will deliver higher education more cheaply and with greater learning productivity in the areas of knowledge easily accessible through information technology.

4. Mass undergraduate education will shift away from human intermediation toward more automated systems dispensing codified knowledge with easily-measured performance indicators.

5. Non-codified knowledge, interpretative ability, and deeper wisdom will be available mostly to a privileged few (the affluent and the best and the brightest); however, even these few will suffer an opportunity loss compared to what humanly intermediated information technology could have provided.

6. The knowledge base will atrophy as research universities falter.

An Adaptive Scenario. In comparison to the business-as-usual scenario, which leaves higher education as a weakened industry, the adaptive scenario envisions higher education as a younger, restructured industry. In the adaptive scenario, colleges and universities succeed in accomplishing the restructuring and re-engineering necessary for adopting an IT-based perspective. Faculty examine and correct the research-teaching balance and work together to optimize the use of IT. They set operationally meaningful teaching and learning objectives, and in the process they examine the comparative advantage of IT and human intermediation at each stage of the educational process. Teaching and learning quality and learning productivity improve.

The adaptive scenario has not one but two possible outcomes. First, one may predict that the adaptations increase the demand for services from colleges and universities to the point where existing faculty resources remain fully employed (though redeployed). It is not hard to find optimists ready to affirm higher education's renewed potential as a growth industry. Jobs in the information age require lifelong learning, and in this scenario, colleges and universities have managed to tap that market. Not only are they involved with educational delivery, but they also continue to work with other industries in knowledge development and application.

The second adaptive scenario is one in which the demand for educational services does not expand; hence the faculty employment base declines. Universities continue to attract traditional students and have managed to contain their costs by substituting capital for labor, including faculty labor, but traditional higher education institutions do not manage to capture the expanding market of nontraditional learners. Even if this second adaptive scenario proves to be the case, colleges and universities would still be better off than in the business-as-usual scenario, since educational quality and learning productivity have improved, marginal and perhaps average costs have declined, and the knowledge base continues to be maintained and developed. However, this scenario would require adjustments to reduce faculty and staff numbers in order to pay the bills for technology.

Divisive Issues

Whether academic productivity should be viewed in the context of higher education as a growth market or in the context of reduced employment has emerged as a lively topic. Will institutions have to reduce faculty size in order to finance IT investments or can these investments be funded from the revenues associated with penetration of new markets or, in the case of public institutions in some states, incremental appropriations from government? The capital-labor ratio rises and the educational model becomes more productive in either case, but the implications for an institution's internal climate--including the barriers to adopting IT--differ profoundly. No one argues that the growth scenario isn't desirable, but some doubt that it will in fact be achievable. What happens if the desired growth cannot be achieved remains debatable.

Higher education's core values will be at risk if more and more undergraduate education shifts to nontraditional providers. By traditional values we do not mean a "canon" of treasured works but rather an investment in areas of inquiry that a corporate or for-profit market may not deem profitable. Sometimes, in fact, the profitability of these ideas may not be visible for many generations; in other cases, as with questions of philosophy or culture, the value is not a fiscal one. Indeed, the most fundamental objective of the classic university, that of nurturing the community of scholars who conserve and advance mankind's intellectual and cultural heritage, may be lost if the educational function in our society is taken over by nontraditional providers. We believe that colleges and universities have a heritage whose sustenance will require the diligence of all those who affirm the importance of the unfettered pursuit of knowledge. Ironically, those research institutions which are most adaptive, most flexible, and most capable of developing IT utilizations seem to have the least incentive to do so. Their very strength permits them to maintain the traditional ways, to defend their faculty's pursuit of the status quo.

In this paper we have tried to identify the most likely routes toward increased learning productivity with information technology, while recognizing that the benefits and applications will vary greatly depending on the subject, the type of institution and the type of student. The cost issue is critical, and the approach to activity-based costing and simulation we describe sets an agenda in that area. The two scenarios we explore, non-adaptive and adaptive, suggest that institutions have a great deal to lose or gain depending on their decisions about technology. Whether or not one agrees that today's colleges and universities have a worthwhile core of values that should be protected or that technology should in part substitute for faculty labor, the potential for increased learning productivity through technology is too great for higher education to ignore. If colleges and universities fail to adapt effectively, other kinds of institutions will take up the challenge.

Charts

Table 1
Course Configurations
(contact hours, frequencies, and class size)

	Weeks per term	Sessions per week	Session length	Class size	No. of sect
Traditional Method					
Lecture sessions	15	2	50	48	6
Breakout sessions	15	1	50	16	18
Studio Method					
Studio sessions	7	1	110	48	6
Discussion sessions	14	1	50	16	18
Voluntary	14	1	50	48	3

Term length is 15 weeks; enrollment equals 288; session lengths are in minutes.

Table 2
Faculty Out-of-Class Time
(hours per week during the term)

	Traditional Method	Studio Method
Teaching preparation	6.5	3.5
Assignment prep. and grading	4.5	2.5
Meetings with students	5.0	2.0
E-mail with students	2.0	2.0
Meetings with colleagues	1.0	1.0
Supervising Preceptors	1.0	0.0
Total	20.0	11.0

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This is the first in a series of white papers on the topic of academic productivity produced by EducomÕs National Learning Infrastructure Initiative (NLII). More information about NLII can be obtained by contacting Educom or by sending electronic mail to NLII@Educom.edu.

Appendix C

Student Attitudes Toward Distance Learning

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One of the important issues in distance education is understanding how students react to learning in a class where members are separated by time and space. Attitude toward learning is an important factor in eventual academic success. Research data on student attitudes toward distance learning can be grouped into four categories: attitude toward the technology, attitude toward distance education teaching methods, attitude toward student and teacher interaction, and attitude toward being a remote student.

Research data indicates that student attitudes toward technology often evolve as student familiarity with the technology increases. Students new to a particular technology may initially exhibit some concern about the role of technology in the learning experience. If this occurs, these students typically demonstrate a reluctance to actively participate in the distance classroom. (1,2) However a series of studies has shown that familiarity with technology over time erodes anxious feelings.(3,4,5) Alternatively, another source of difficulty linked to technology has surfaced in some student comments about frustration resulting from equipment design or function problems, such as poor sound or an inability to see or speak with the instructor. (6) For this reason, it is important for distance educators to comprehensively plan an effective learning system for remote locations from both an instructional design as well as a technology design perspective. On balance, several studies have revealed no significant negativity in student attitudes about the use of technology in teaching and learning. (7,8)

Student attitudes toward distance learning are frequently affected by the teaching methods used. Research has suggested that teachers who know how to make the most of the available technology are judged as more successful than those who approach technology as an add-on to a traditional class. Students prefer some teaching strategies over others in a distance learning environment. They prefer engaging in small group discussion or interactive question and answer to viewing lectures. (9,10) In addition, proctors well-trained in the special needs of distance learning students and the use of technology can greatly facilitate the teaching and learning process. (11) When instructors are not well-trained in the use of technology, they may spend time adjusting equipment at the expense of teaching the class, as was the case in one study of distant student attitudes. (12)

Student-teacher interaction also plays an important role in student attitudes about distance learning. Studies have shown that student attitudes toward distance education can be significantly affected by facilitating some degree of interaction among students and teachers. (13,14,15,16) For example, at least one visit by the teacher to distant sites has positively affected distant learners' attitudes. (17) Instructors can also facilitate interaction through regular individual contact with students via telephone or electronic mail.

Finally, student attitudes about being distance learners affect their outlook about distance education in general. Older students are typically more enthusiastic and structured in their approach to distance learning. (18) Perhaps this is due to maturity and recognition of the value of convenient distance course opportunities. Studies have also demonstrated that students believe that they learn as much--if not more--via two-way television as they do in a traditionally delivered course. (19) It is important to note that those who have taken distance courses have generally responded positively to the experience and would recommend it to other students. (20,21,22,23,24)

Student attitudes about distance learning are frequently linked to components of the distance education experience, rather than generalized about distance learning in total. The use of a variety of teaching methods with a de-emphasis on lecture delivery is preferred by distance learning students. Positive student pre-disposition to being a remote learner contributes to learning enthusiasm. Attention to teacher-student interaction is important, since distance learners exhibit a strong bias toward personal contact with the instructor. Students who are initially anxious about using technology for learning usually become increasingly comfortable as their exposure to it increases. Thus, distance educators should examine the range of factors influencing student attitudes when planning a distance education course.

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Needs of Distance Learners

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Distance education students often face a number of obstacles--they may be constrained by home or work circumstances, geographically removed from learning resource centers, isolated from other learners, and uniformed about course administrative issues. These factors give rise to special needs which must be met if distance learning programs are to be successful. (1) Research indicates that educators planning to implement distance learning programs will need to address the special needs of remote learners including: advising needs, access needs, communication needs, and administrative needs.

Advising and counseling often require attention to issues that are unique to distant learners. The obligations that compel students to take distance courses might carry job- or family-related pressures such that students may require special counseling for help with managing time and coping with varied responsibilities. (2,3) Because distant learners are often returning to school after years of absence, significant pauses in their education might need to be accessed and remedied. (4) The diversity of distant students' circumstances means that their courses must be appropriate for a wide variety of cultural and individual learning differences. (5,6,7,8)

Access to learning resources, whether the instruction itself or supporting resources, must be thoroughly planned and often depends upon communications technology. Distance learning most often requires basic access to, and understanding of, workable information systems, including the technology by which instruction is received. On-site facilitators or regional study centers can be useful in bridging technological gaps between teachers and students. (9) Also, students often require some form of access to library systems. (10) If they are unable to physically visit the institution's library, courier systems, on-line searching capabilities, statewide library networks, inter-library loans, or some other means of access might be necessary.

Geographic isolation from the instructor and possibly other learners requires special sensitivity on the part of the teacher in constructing effective communication channels between class participants. The teacher can ease feelings of isolation by ensuring that he or she is accessible via telephone (preferably a toll-free number) during "telephone office hours," for occasional in-person visits, and by electronic mail, thus allowing for direct instructional feedback. (11) Isolation from other students might require the development of direct communication among peers such as occasional teleconferencing, (12) or computer bulletin boards set up for individual classes.

Organizational policy issues with regard to course and support system administration can often be invisible to distant learners, creating a sense of frustration about the appropriate procedures and contact persons. Distance from central administrative services can result in a lack of information about course policies, the enrollment process, or even the existence of a course. Clear administrative contact information and course advisory services are therefore important aspects of distance support systems. (13) One effective approach is to conduct administrative and academic support services as a service-oriented business, determining the services to be offered by analyzing those in the target market for distance education courses. (14)

The needs mentioned above can be met through institutional support structures. Nevertheless, distance students themselves must take some responsibility in addressing their own needs. Perhaps it is best if this is explicit communicated to learners. For example, distance learners must: 1) assume greater responsibility for their own learning, 2) become more active in asking questions and obtaining help, 3) be respectful of the flexibility required by other students, and 4) be prepared to deal with technical difficulties in the two-way flow of information. (15)

In summary, distant educators must be prepared to address the wide range of needs unique to distant learners. They should plan to include the special resources necessary to integrating distant learners with the main site. Particular attention should be paid to advising services and administrative policies such that they meet distant learners' needs. Instructors need to identify and establish effective communication channels among class participants. Access to the full set of instructional resources that distant students will require should be established whether this is via communication technology or more traditional means.

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Professional Development for Distance Educators

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Professional development for distance educators is most effective when it: addresses teachers' needs, includes instructor input, offers opportunities to develop a range of teaching skills, utilizes a variety of instructional methods, and includes appropriate incentives. Research on professional development in distance education centers on the classroom instructor's ability to use and teach with technology. Ideally, faculty development programs are based on the goals of: 1) helping instructors identify life-long values in such training, 2) assisting instructors in becoming more creative and better problem solvers, and 3) stimulating curiosity and increasing enthusiasm. (1)

To do this, a "bottom-up" approach is recommended where instructors' needs drive the development agenda. (2) Faculty exhibit three concerns about training: self-concerns (how will this affect my job?), task-concerns (how will this change class instruction?), and impact-concerns (how will this affect student learning and achievement?). Several researchers state that the best way to get technology into learners' hands is by showing instructors how to perform daily tasks with technology. (3,4,5,6) In-service trainers are more effective when they can deal with the real problems that confront practicing teachers. These needs include curriculum integration, instructional design, research findings, and hardware/ software availability. Access is the primary obstacle facing teachers in the classroom integration of technology. Some schools loan teachers school equipment over vacations, thus empowering teachers with technology. (7,8)

Organizations should adopt a structured procedure for including faculty input in professional development. By doing so, instructors are provided a personal stake in the planning and implementation of these activities. (9,10) Some organizations use their own instructors' special expertise with specific equipment or classroom issues to provide support for others. (11,12) The results are a sense of ownership of professional development, innovation designed by people who know the organization's policies and structures, and an effective reorganization of the workplace.

Research about professional development in distance education has addressed the importance of teaching skills in effective instruction. Several studies emphasize that distance education professionals must often be much more than teachers, taking on the roles of counselor and administrator as well. The variety of roles that are required of distance education instructors necessitates strong skills in communication (written, telephone, and interpersonal), persuasion, encouragement, organization/management, needs assessment, and up-to-date knowledge about the organization's course offerings and administrative processes. (13)

The most important element of professional development is an emphasis on effective instructional methods. A common flaw is the emphasis of information transmission rather than the provision of opportunities for hands-on practice. (14) Some professional development models emphasize the use of practice, feedback, and teacher-mentors to guide classroom implementation of technology. (15,16,17,18) Others incorporate the concept of "coaching" the use of technology, where a technical expert assists the teacher with instructional design and execution - with guided feedback - until the teacher becomes comfortable with the process. Specific methods of instruction have included collaborative learning (grouping teachers by level of expertise, experience, or subject area), using distance technology to conduct training courses and discussion groups, and placing teachers on course design teams with technology experts.

Appropriate incentives and recognition are critical to gaining faculty participation in the professional development programs. Aspects that should be examined when structuring faculty development programs include: the provision of time and support resources for observing successful instructors, experimenting with technology, and integrating it with the curriculum; peer recognition programs; and provision of monetary or professional incentives (e.g., release time). (19,20,21)

Any efforts to structure professional development must be based on a clearly articulated set of goals and policies, a plan to provide the skills necessary to such instruction, implementation with full participation of teachers, and evaluation to continue the development process. (22,23) Instructors need to understand the value of participating in development programs and be offered ample opportunities to plan and implement portions of the programs. Faculty development offerings which offer participants hands-on practice with a range of teaching skills are most effective.

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Summary of Quality Issues in Distance Education

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A primary concern of distance educators is providing a high quality educational experience for students with the goal of developing independent and self-reliant learners. (1,2) To meet this goal, three approaches are commonly advocated: a service model of education, stakeholder analysis, and different methods of evaluation.

The service model of education approach encompasses a range of techniques, each focused on the integration of quality into distance education courses. One technique involves the incorporation of quality assurance methods into the design of courses and curricula. A corollary technique calls for high quality learner support services that promote and support, if not face-to-face then at least voice, contact with instructors and support staff. (3) Ideally these student support services should be integrated into the course design from the beginning rather than viewed as an add-on to a course. (4)

Another technique for including quality assurance techniques from the start of a distance education program is to integrate the study of communication itself into the curriculum. The philosophy behind this technique is that developing the learner's "ability to question the very pedagogy and the very system of communication" will promote learner confidence and independence as well as maximize the student's time with the teacher. (5)

Some researchers suggest that a broader, more comprehensive approach to providing a quality educational experience will result from employing a customer service or Total Quality Management model. A customer service approach defines the customer as learner and focuses on the needs of the learner to guide design of quality teaching methods and materials. (6,7) The effective and independent learner is the desired product of this process, and a quality educational experience will focus on the process of learning rather than the content. The Total Quality Management model incorporates these notions and seeks to arrive at a definition of quality through a consensus process. (8)

The second approach to achieve quality, stakeholder analysis, focuses on defining quality for distance education. The most agreed upon method involves forging a consensus between the various people who have a stake in the educational process, the stakeholders. (9) Stakeholders can include the learners, the continuing education unit, the faculty, industry, the community, etc. (10,11) By including these stakeholders in defining quality, it is argued, a more useful and appropriate benchmark of quality is created. This definition can include elements measured quantitatively, such as: drop out rates, response rates on assignments, evaluations by the students. (12) The definition can also include elements measured qualitatively, such as: the quality of the learning-teaching package, the process of learning, the degree of freedom in pace, content, etc., and the level of independence of the students. (13)

An example of the definition of a quality educational experience arrived at through consensus included the following elements: the quality of learning materials, the availability of materials, support for students through well trained staff, a well managed system, monitoring and feedback mechanisms to improve the system. (14) "Quality, whether it is in the system, its management, materials or learning effectiveness, indicates that what is required is doing the job effectively and appropriately. Quality has the characteristics of being well thought out, prepared with care, implemented with responsibility, has a firm direction but is flexible enough to cope with contextual variation, and is positively responsive to comment and criticism." (15)

The final approach to ensure quality involves evaluation of distance education programs once they are established. One technique is to employ qualitative assessment techniques to understand why a student would perform well or poorly in a distance learning environment. (16) another technique is to use quantitative evaluation to provide indicators of quality. (17,18,19) In Norway an effort was made to standardize evaluation by developing evaluation guidelines for all distance education projects and by systematizing the experiences, theory, and methods of evaluation. (20) Others argue that evaluation should be performed in a very contextual way, that is on a case-by-case basis (21) and in tandem with the appropriate stakeholders. (22,23) This technique argues that because definitions of quality are relative, it is not useful to attempt a "neutral definition;" instead one should work towards a definition that has meaning for those involved in the process. (24)

Ensuring high quality in distance education programs is a top priority of distance educators. It can be a critical component in the development of independent and self-reliant learners. Quality can be approached as an integral part of distance learning programs, using such techniques as Total Quality Management, to establish quality throughout a program. Quality can also be addressed by consulting stakeholders in the distance learning programs and forging consensus about elements of quality. Qualitative and quantitative evaluation can also be administered to determine quality achievement and to highlight areas of concern.

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Appendix D

The Naval Academy:

Ready to Address the Navy's Computer Training Problem

by

Midshipman 1/c Peter J. Sheehy

Professional Writing

LTC Barton, USA

24 April, 1997

Hackers, viruses, crashes, break-ins, and information warfare are all potential problems that accompanied the Navy's emergence into computer world. One problem that appears to have been overlooked, however, is the Navy's lack of training. While the Navy has dedicated large amounts of its resources to procuring and implementing computer technology, it has failed to adequately train personnel in the computer field. Currently, no enlisted or officer computer specialty exists in the fleet, and the gap between the complexity of the equipment and the knowledge of the operators will only become wider as technology improves. While the problem of computer literacy needs to be addressed at all levels, the Navy has one resource that it can tap almost immediately: the Naval Academy. Despite the vast amount of existing computer resources at its disposal, the Academy has yet to introduce a formalized brigade-wide computer training program for midshipmen. Each year, approximately fifteen to eighteen percent of newly commissioned line officers are academy graduates.[1] By implementing a formalized training program, the Naval Academy could feasiblely instill almost twenty percent of future naval officers with computer skills that are essential to understanding and fully utilizing the resources they will encounter in the fleet.

As technology increases the capabilities of computers, the Navy's reliance on computers will also increase. The Navy's first "Smart Ship," USS Yorktown (CG-48), already employs an on-line computer system that monitors trends in machinery performance. This represents a considerable deviation from the Navy's periodic time-based preventive maintenance system (PMS).[2] The ship's computer operating system runs on Windows NT and many of the workstations around the ship are networked PC's. One automated system, the Integrated Bridge System (IBS), allows the ship to be piloted from the combat information center. The system improvements on board the Yorktown have already drastically altered the watch bill by reducing the number of watch standers by twenty. With greater budgetary cutbacks looming in the future, solutions like the Smart Ship program are almost inevitable.[3]

The navy is becoming "paperless." Already, almost every command in the navy utilizes PC's and computer networks to keep records, share data, and perform many of the logistical functions that were performed manually in the recent past. Computer assisted briefs, laptops, and command webpages are becoming standard. The Navy recently formulated an information technology directive for the 21st century called "IT-21." According to a CINCPACFLT message promulgated in January of 1997, "IT-21 is a fleet driven reprioritization of C4I programs... to accelerate the transition to a PC based tactical/ tactical support war fighting network." The plan's fleet-wide adoption of specific commercial network operating systems (NOS) will decrease the diversity of training, operational procedures, and troubleshooting requirements.[4] Eliminating the multitude of diverse operating systems present in today's fleet will also facilitate future wide-scale computer training.

Granted, people still often perform their everyday jobs with little knowledge about computers. Improved technology has created graphical user interface (GUI) programs that, like applications that run on Microsoft Windows 95, require little more than a mouse and a high school education to manipulate. Computer-assisted briefing, word processing, and data processing are often used out of convenience rather than necessity. Even when contact with computerized systems is imperative, people can generally learn the essentials of everyday operation or "the gouge," without actually understanding how the system works or its capabilities.

Allowing sailors to be ignorant of the capabilities of computers and computer integrated systems, however, impedes improvement. How can people improve existing systems if they are ignorant of available resources and alternatives? In a recent visit to the Naval Academy, Captain McCall, prospective commanding officer of the SSN 21 Seawolf, elaborated on the technological complexity of the Navy's latest addition to the submarine force. He also commented on the benefits of young officers entering the fleet with higher levels of computer knowledge and added this sea story to illustrate his point: After mentioning, in passing, the possible benefits of converting the sub's periscope video images into a digital format and sending them ashore electronically, a young officer spent his next evening of liberty at his local computer software store. For about one-hundred dollars, the young officer purchased, and then installed, the software needed to satisfy the Captain's half-hearted request.[5]

If "the gouge" or basic computer literacy continues to be accepted as a substitute for "system competency," combat readiness goals like Joint Vision 2010 will never materialize. Like each service's war fighting vision, Joint Vision 2010 provides direction and goals for the future. Soon, plans like Joint Vision 2010 Battlefield Dominance will make "system competence" a necessity. "Information superiority is the foundation of Joint Vision 2010 Battlefield Dominance, as well as the war fighting vision for each service."[6] Today, when a computer system breaks or malfunctions, the Navy invariably calls upon civilian technicians to analyze and fix the problem. Some commands are lucky enough to have a computer "whiz" within their ranks. These "whizzes," however, are rare, and usually obtained their computer knowledge before they entered the Navy or through their own initiative. Such resources may not always be available. Where will civilian technicians be during combat? In the past, the CO or the "salty" chief were the experts, and they knew every aspect or capability of the equipment around them. With the introduction of highly technological equipment over the last few years, however, senior officers and enlisted have often been cut out of "the loop." The navy needs to give its people the computer knowledge to understand the systems it expects them to operate and sometimes fix. A basic understanding of programming language, networks, and programming techniques could pay immeasurable dividends in the Navy's ability to trouble-shoot most computer problems. Even though hardware and software are changing all the time, most changes are merely improvements to existing systems. Learning existing software and hardware would not only facilitate the learning of future applications, it "would go far toward breaking the current computer-phobia prevalent in the fleet."[7]

Unfortunately, the Naval Academy is not immune to computer-phobia either. In order to prepare its graduates to assume leadership roles in a highly technical Navy, the United States Naval Academy's core curriculum requires midshipmen to take courses on electrical engineering, weapons and control systems, and thermodynamics. The Academy's core curriculum does not, however, require midshipman to take courses on computer programming, networks, or even computer basics.

With some working knowledge of a word processor, a spreadsheet program, and electronic mail, midshipmen can adequately carry out the tasks required of them at the academy. Though various engineering departments often incorporate use of computer aided design programs (CADS) into their courses, midshipmen generally know enough to complete the task at hand and little more. In a polling of the one hundred and twenty midshipmen in 11th Co., less than 40% have ever removed the casing from their system units to see what was inside.[8] On average, each midshipman polled has had their issue computer for two years. Such lack of exposure can partly be attributed to the Naval Academy's treatment of computer issues in previous years.

Until the class of 2000 received their computers in September of 1996, the academy maintained computer contracts with Zenith. Contrary to the advice of a faculty board that evaluates the academy's computer acquisition process yearly, the supply office of the academy apparently based its choice of computer maker on cost rather than quality.[9] Proprietary and with little room for expansion, issue computers were perceived to be inferior by many midshipmen and were often disregarded as a serious learning tool. The proprietary nature of Zenith and the limited computer hardware components available to midshipmen at the academy discouraged midshipmen from upgrading their machines or even opening them up to learn about them. With the issue of Data Experts computers to the class of 2000 and the expectation of an even better quality computer for the class of 2001, problems of quality, upgradability, and midshipman interest could be alleviated. Training midshipmen to take advantage of the improved resource that will rest upon every midshipman's desk remains as the only obstacle the academy has left to address.

The Academy has the resources for "system competency" training. In addition to every midshipman having his or her own computer, the Naval Academy has lab rooms full of Pentium and 486 computers. The Academy's main network (NADN) and many local area networks (LAN) could easily support the training requirements of a brigade-wide training program.[10] The Computer Science Department already offers elective courses on networking, Java, and information systems for the junior officer. Each of these courses contains information that would be valuable in the fleet.

Because midshipmen are already required to take at least 140 credit hours over four years, adding three additional courses to the core curriculum would not be feasible. Despite a Computer Science Department faculty of only 12 members and existing credit hour requirements, the Academy could accomplish computer training in many ways. With additional faculty, the Computer Science Department could offer a course which contains a scaled down mixture of the information systems, networking and Java courses. While such a course could not delve into every aspect of computers, it could give midshipmen a sound understanding of computers and encourage self-teaching. The core curriculum also requires midshipman to take three semesters of Naval Science. NS100 could integrate basic computing skills, such as using the Internet and operating systems, while NS200 and NS310 could introduce more advanced computer skills like programming language, programming techniques, and networks. These portions of the Naval Science curriculum would not necessarily need to be taught by computer scientists. With limited training, some previous computer knowledge, and adequate supplemental text, various faculty from all the departments could assist in these portions of the Naval Science Courses.

Ward Hall, the Academy's computer services building, could also contribute to brigade-wide computer training by informing midshipmen of the new computer technology being implemented on the Academy's yard and in the fleet. Each of the brigade's thirty companies already has a midshipman information services liaison officers (MISLO) who channels information between Ward Hall and midshipmen. After receiving the required training or information from Ward Hall personnel, these "mislos" could update their respective companies with briefs or general military training (GMT) sessions that would not intrude on the academic schedules of midshipmen. Most midshipmen are unaware of the software available to them through Ward Hall and the possibilities that NADN offers. Again, this type of training would increase computer familiarity and spark midshipmen's interest by exposing them to practical applications in the fleet and on the yard.

As the Navy continues to procure and integrate computers into the fleet, the training deficiency of its personnel will become more apparent. The same principles that justify sending every member of the submarine community through rigorous nuclear power training should also apply to computers. The possibility of future combat situations and budget cuts demands that the Navy give its people the necessary skills to maintain and fully utilize the computer-integrated equipment in the fleet. Efficiency, improvement, and combat readiness will be the long term results of this crucial training. Possessing the resources to begin computer training almost immediately, the Naval Academy can begin closing the gap that is developing between sailors and the increasingly complex equipment they operate. By utilizing its computer facilities, the faculty's knowledge, and Ward Hall's expertise, the Naval Academy can accomplish computer training at a minimal expense and continue to send system competent officers into the fleet.

Notes

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2 JO2 Jones, Davy. "Former NPS Dean Explains 'Smart' Effort."Online. Internet. 17 Mar. 1997. Avail. Http:/www.pao.nps.navy.mil/sma.html

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4 Captain McCall. Address. Brief given to Dolphin Club. 23 February 1997.

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8 Fischer, Allan. Personal Interview. Interview with Ward Hall Information Services Liaison. 13 February 1997.

9 Fischer, Allan.

Appendix E

Appendix E

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Classroom Design Principles to Improve Teaching & Learning
Dr. Daniel Niemeyer
(http://www.classrooms.com)

Empower Faculty
Provide the enabling technology that faculty request in enough campus classrooms to meet faculty requirements. Pedagogy should drive the design. The resources faculty request most in a classroom are (1) Blackboards, (2) Overhead projectors, (3) Slide projectors, (4) Television and videotape players and (5) Computers/computer projection. In addition, audiotape/CD players, film projectors, videodisc players, laser pointers, portable computer projectors and other visualizing devices should be available upon request.

The design should focus on a user-friendly approach with a great deal of attention devoted to simple, operational signage and controls. Faculty should be able to operate equipment at eye-level without undignified crawling around on the floor or fumbling with poorly labeled controls in the dark. In addition, dual window coverings, multiple screens, functional light switching and ceiling fans give faculty control over the classroom environment.

Emphasize Flexibility
View a college classroom as a room of a dozen users in several disciplines with multiple teaching styles. Designs should include many options while excluding very few. Keep expensive, long-term items generic. Inexpensive items can be more specific.

For maximum flexibility, faculty should not need to schedule any equipment. The technology that faculty need must be permanently placed in the classroom. Physical delivery of equipment is inefficient. Cabinets or closets are needed in each classroom for storage. The presentation space in the front of the room is precious. It should be covered with blackboards and multiple screens so you can use the board and project images at the same time. It must permit the simultaneous display of multiple images for comparing and contrasting. It should be easy to change as presentation technologies evolve and screen proportions widen.

The front center of the room needs to accommodate overhead projectors, walking space for pacing professors, and open space for displays and experiments. Any lectern for a computer needs to be small and placed at the right or left front of the room, allowing the professor to face the students.

Stress Simplicity
Make all classroom technology, especially computers, as simple, friendly and non-intimidating as possible. Massive teaching bunkers full of intimidating multimedia hardware, invariably requiring the assistance of a technician, does not seem to be the most desirable model. Faculty should not be expected to load necessary software and data files in the few precious minutes between classes. Complex installations tend to be awkward and expensive to change and require almost continuous upgrading.

Begin designing technology classrooms with things we know. There is never adequate time to wire together a display system between class periods, therefore the display system must be built in. Faculty do not and should not tolerate a massive desk/console that creates a psychological barrier between teacher and students. Faculty don't want to push a lot of buttons to make things work.

Consider a design that uses simple, reliable, faculty-requested media, and portable computers. Install video/data projectors in the rooms and provide a user access panel that requires just one cable connection from the computer to a small lectern. Have faculty bring a laptop computer, loaded with the necessary configurations, applications and files, into smart classrooms.

A user-friendly, eye-level interface panel makes it possible to show campus cable TV, VHS videotapes, as well as computer displays from IBM's and Mac's, plus workstations. The addition of computer projection should not make simple devices like overhead transparencies, slides and television more difficult to use.

Expand Connectivity

The greatest change in the history of classrooms is occurring during our lifetime. Classrooms are changing from the most isolated places on earth to the most interconnected. In technology classrooms, there is a need for connectivity to outside teaching resources. Telephone lines (twisted pair), TV distribution (coax) and Data Connections/Fiber Optics, Ethernet connections or ISN installations make it possible to interact in real time with distant individual personal computers, workstations, databases, or banks of stored text and images.

There is growing demand for classrooms to be able to originate courses for distance education. Several video compression possibilities exist for distribution. While the possibility of infrared, wireless connections, looms on the horizon, it is still prudent to include a generous amount of conduit in any classroom design.

Contain Costs

Technology classrooms must serve the faculty well yet remain affordable. In order to really impact teaching, many smart classrooms need to be created around the campus, not just one expensive island of technology to impress VIPs. The technology design should focus on self-service classrooms to reduce costs for continuing staff support.

Sweat Details

Define the specifications for lighting, room layout, seating, blackboards, eye-level controls, signage, acoustics, conduit, windows and coverings. Scrutinize the guidelines for screen size and mounting height. Verify adequate overhead projector space and teacherÕs space in the front of the room. It is critical, for example, to prevent room light from washing out the images on the screen. During projection, room light should be bright enough for student interaction, not just dim for note taking.

Blackboard lighting must be controlled to minimize ambient light falling on the screen and light is needed at the computer lectern.

What Is a Media-equipped Classroom?
Dr. Daniel Niemeyer
(http://www.classrooms.com)

One could consider three levels of college classrooms:
Level One*:*
Classrooms where no technology other than chalkboard and screen are provided.

Level Two:
Basic AV-Equipped Classrooms contain television sets or large screen video projectors, videotape players, slide, film and overhead projectors plus liquid crystal display panels and microphones when necessary as well as the screens, cabinets, fold-down tables, AC power, Cable TV, Speakers, Lighting to make them work effectively. Basic media-equipped classrooms do not include computing interconnection.

Level Three:
Smart Classrooms are high technology, computer connected, classrooms.

The Basic Media-equipped Classroom
A media-equipped classroom provides the basic enabling technology that college teaching requires. The resources faculty request most in a classroom are (1) Blackboards, (2) Overhead projectors, (3) Slide projectors and (4) Television/videotape players. In addition, audiotape/CD players, film projectors, videodisc players, laser pointers, portable computer projectors and other visualizing devices should be available upon request.

For maximum flexibility, faculty should not need to schedule any equipment. The technology that faculty need should be permanently placed in media-equipped classrooms. Professionals agree that more damage is done to equipment in transit than in use and physical delivery of equipment is inefficient. Classroom scheduling needs to fit classes that need basic media support into these media-equipped classrooms.

The challenge to universities is to combine the expertise of media, library and computer staff with architects and facilities' planners to focus on faculty presentation needs in the classroom. Then, these ideas need to be shaped into practical, functional teaching/learning environments at reasonable cost.

Faculty teaching large classes often teach in operator-assisted lecture halls where projection booths serve as the coordinating location for media support. Two film projectors, two slide projectors and two overhead projectors, cordless microphones, sound amplification systems, large screen video projectors and motorized screens are standard.

Smaller classes are scheduled into self-service, media-equipped classrooms, geographically distributed throughout the campus. A built-in media cabinet in these classrooms is important.

Physically, it provides a secure base to mount the television receiver at approximately instructor-head-height. Practically, it provides a secure delivery receptacle. Most important, psychologically, it makes the media an integral part of the instructional environment, like the chalkboard. Technology is not just an afterthought.

A centrally-schedule, college classroom is a room of a dozen users in several disciplines with multiple teaching styles. Designs should be inclusive, offering many options while excluding very few options. Expensive, long-term items should be generic. Inexpensive items can be more specific.

The design should focus on a user-friendly approach with a great deal of attention devoted to simple, operational signage and controls. Faculty should be able to operate equipment at eye-level without undignified crawling around on the floor or fumbling with poorly labeled controls in the dark. In addition, dual window coverings, multiple screens and functional light switching give faculty control over the classroom environment.

The presentation space in the front of the room is precious. It should be covered with blackboards and multiple screens so you can use the board and project images at the same time. It must permit the simultaneous display of multiple images for comparing and contrasting. It should be easy to change as presentation technologies evolve and screen proportions widen. The front center of the room needs to accommodate overhead projectors, walking space for pacing professors, and open space for displays and experiments.

Conflicting demands are placed on college classrooms. They need to be designed to accommodate the widest variety of faculty requests: a screen in the front of the room; switches to control banks of lights parallel with the front of the room and window treatment to minimize ambient light on the screen; a fold-down table to accommodate a film or slide projector with a power outlet close by; a desk, table or rolling cart for an overhead projector in the front of the room with power nearby; a locked media cabinet/closet that provides storage for a videotape player; a film, slide and overhead projector; audiotape player; LCD panel; and a television receiver on top of the media cabinet in classrooms or a ceiling-mounted video projector in larger lecture halls. Display systems must be capable of receiving signals from television, videotapes, laserdiscs, CD-ROM and computers.

Lighting, acoustics, and seating must be coordinated with the specialized requirements of each medium, and each component must be researched and integrated into the classroom design.

Classroom technology, especially computers, should be as simple, friendly and non-intimidating as possible. Massive teaching bunkers full of intimidating multimedia hardware, invariably requiring the assistance of a technician, is not the most desirable model. Complex installations tend to be awkward and expensive to change and require almost continuous upgrading. The addition of computer projection should not make simple devices like overhead transparencies, slides and television more difficult to use.

Target 30% of general-purpose, campus classrooms as potential media-equipped classrooms. Include a variety of small, medium and large classrooms and lecture halls and make sure that they are geographically spread around the campus. Match the classrooms with data on faculty, courses and departments that use a lot of media in their classes.

Guidelines are necessary to communicate media requirements to administrators, architects, and contractors, but each classroom requires individual interpretation and exceptions. Technology guidelines for standard classrooms (up to 75 students), large classrooms (75-150 students) and lecture halls (more than 150 students) will vary, but in each case the emphasis should be on easy to use hardware, user-friendly controls and clear signage.

Resources Provided in Media-equipped Classrooms & Lecture Halls

Each Media-Equipped Classroom contains:

Media cabinet or closet to house equipment
Projection screen(s)
Overhead projector
Television or large screen projector
VHS videotape player
Fold-down projection table in the rear of room
16mm film projector (on request)
35mm slide projector (or request)
Liquid crystal display panel (on request)

Each Media-Equipped Large Lecture Hall includes:

Cordless Microphones & Speakers for Voice Amplification
Projection Screens
Overhead Projectors
Large Screen video projector
16mm film projectors
35mm slide projectors
VHS video tape player
Laser pointer
Audio cassette player
Liquid crystal panel

Role of a Media Center in Classroom Design & Support

Dr. Daniel Niemeyer
(http://www.classrooms.com)

The challenge to universities is to combine the expertise of media, library and computer staff with architects and facilities' planners to focus on faculty presentation needs in the classroom. Then, these ideas need to be shaped into practical, functional teaching/learning environments at reasonable cost. Today's university students will spend the rest of their lives working with technology. They must become comfortable with it in the college classroom.

A number of universities are beginning to take a close look at college classrooms, where a typical undergraduate spends 400 hours each year. Interviews at MIT revealed that faculty and students had a strong interest in creating warmer, more intimate, and more attractive classroom spaces that promote faculty-student exchanges. Attractive classrooms lend dignity to the learning process. Dingy classrooms--especially if administrative, research, science, and athletic facilities are handsome--suggest that classroom teaching is a lesser enterprise.

University of California at Davis researchers concluded that there is a need to create diversity among classrooms. Sameness is often equated with being boring or dull. Differences help orient oneself in a building and make it easier to communicate about a room to others. Too often, college classrooms are described as ugly, stark, cold, grim, spiritless, windowless and colorless.

Conflicting demands are placed on college classrooms. They need to be designed to accommodate the widest variety of faculty requests: a screen in the front of the room; switches to control banks of lights parallel with the front of the room and window treatment to minimize ambient light on the screen; a fold-down table to accommodate a film or slide projector with a power outlet close by; a desk, table or rolling cart for an overhead projector in the front of the room with power nearby; a locked media cabinet/closet that provides storage for a videotape player; a film, slide and overhead projector; audiotape player; LCD panel; and a television receiver on top of the media cabinet in classrooms or a ceiling-mounted video projector in larger lecture halls. Display systems must be capable of receiving signals from television, videotapes, laserdiscs, CD-ROM and computers.

Lighting, acoustics, and seating must be coordinated with the specialized requirements of each medium, and each component must be researched and integrated into the classroom design.
Faculty teaching large classes often teach in operator-assisted lecture halls where projection booths serve as the coordinating location for media support. Two film projectors, two slide projectors and two overhead projectors, cordless microphones, sound amplification systems, large screen video projectors and motorized screens are standard.

Smaller classes are scheduled into self-service, media-equipped classrooms, geographically distributed throughout the campus.

A built-in media cabinet in these classrooms is important. Physically, it provides a secure base to mount the television receiver at approximately instructor-head-height. Practically, it provides a secure delivery receptacle. Most important, psychologically, it makes the media an integral part of the instructional environment, like the chalkboard. Technology is not just an afterthought.

Media Center - Classroom Support Responsibilities

Establish a Series of Media-equipped Classrooms on Campus

Tour every centrally scheduled classroom on the campus. Notice the layout of the room, the suitability for projection and cable TV. Target 30% of the rooms as potential media-equipped classrooms. Include a variety of small, medium and large classrooms and lecture halls and make sure that they are geographically spread around the campus.

Be involved with the long range planning and the space management groups on campus so you know what plans exist for campus classrooms. Have guidelines ready for distribution to architects and planners for any new construction. Offer to check all blueprints for conduit, electrical outlets, cable TV drops, screen sizes, lighting, sightlines, etc. Be a vocal advocate for classroom upgrades, improvements and construction. (Many campuses do not have a classroom champion.)

Keep your eyes open for a few particularly dingy, unpopular, stuffy, noisy classrooms that have potential for improvement. Work with interested individuals to locate one-time funding to dramatically improve the classroom physically and, of course, media-equip it.

Be involved with the Classroom Scheduling Office so that you have access to the courses and faculty scheduled into each classroom. Work with faculty and departments that are heavy media users, then renovate, upgrade and media-equip classrooms that they often use.

Inform Faculty about Media-equipped Classrooms

Using the data base from the Classroom Scheduling office, locate each faculty member teaching in a media-equipped classroom. Send each teacher a postcard describing the hardware available in the media-equipped classroom, and how to access it. Send feedback letters to faculty each semester to help the media center be more responsive to their needs, and to permit them to make suggestions on service improvements. Issue frequent stories about media-equipped classrooms -- features, locations and how to schedule classes into them.

Classrooms at the Media Center

The Media Center needs a couple of model media-equipped classrooms that faculty can schedule on an occasional basis.

These classrooms can be more flexible than the other media-equipped classrooms on the campus and they can be equipped with a wider array of equipment. In addition, they can be used to introduce and test technology new to the campus.

Create a Media Rental Service

Campuses need media rental services. Whether it is film projectors for the Athletic Office, slide projectors for a conference or TV /VCRs for students, the media center can operate a full-cost recovery AV/TV rental service for the campus community.

Develop a Service Orientation

With the three components in place, (a) media-equipped classrooms on campus, (b) model classrooms in the media center and (c) a media rental service, routine equipment needs can be met fairly easily, and attention can be placed on the unusual, last-minute, one-of-a-kind requests that can add so much to the image of a service oriented unit. The service orientation should permeate the media center from the director through the technicians to the front line secretaries and clerks who account for the majority of the interactions with the campus clients.

With a strong classroom support unit, the other areas of the media center, television and audio production, technical support, film/video library and graphics, will be able to count on accessible, reliable facilities in the classroom to display the courseware they provide to faculty. Growth in other areas of the media center builds on the increased capability in the classroom.

Media Center - Classroom Support Personnel

A cadre of professionals is necessary to support the media-equipped classrooms. The equipment has to be designed, installed, cleaned, checked, maintained and, when necessary, replaced. The staff must have technical expertise, but more importantly they must have a customer-service orientation. They spend just a fraction of their time at a bench repairing equipment while they devote most of their time and efforts working one-on-one with faculty.

Staff to Support 60 Media-equipped Classrooms And 9 Lecture Halls

The University of Colorado at Boulder employs a full-time electronic specialist/manager, three full-time audio-visual technicians, a half-time closed-circuit TV specialist, a full-time clerk and 45 part-time student operators.

In the sixty self-serve media-equipped classrooms, training and limited operational support is provided for the faculty. In the nine operator-assisted large lecture halls, full operational support is provided by student operators from the media center whenever requested by faculty.

At least one evening each week, all hardware is inspected, tested and cleaned. It is especially important to remove chalk dust from the face of the television receiver and from the stage of the overhead projector. The weekly check ensures that all equipment will appear professional and meet the operational requirements of the instructor.

During the first week of the semester, letters outlining the capabilities of the equipment and the procedures for accessing media center hardware are sent to instructors who are scheduled to teach in the media-equipped classrooms. Conscious decisions were made to create a simple, user-friendly environment, with intuitive and common sense design, allowing faculty to use media successfully with the least amount of idiosyncratic knowledge.

Following an initial capital investment, a plant fund of at least 5% of the value of the classroom hardware is needed each year for equipment renewal and replacement. Continuing equipment replacement will cut the labor-intensive costs of repair and maintenance, permit the staff to devote more time to faculty than to hardware, and will support the image of the media center as having modern equipment and facilities.

Media Support in Non-media-equipped Classrooms

When faculty discover that they need media, but are not teaching in a media-equipped classroom, an associate director of the media center might:

a. Check with "classroom scheduling office" to see if a media-equipped room is available.
b. Offer short-term use of a media-equipped classroom in the media center.
c. Suggest that faculty use their own department's equipment or borrow what's needed from a department in the building in which a course is taught.
d. Suggest that the department rent what is needed from a rental pool.
e. Provide emergency semester loan of a piece of equipment.
f. Suggest that the department purchase equipment with departmental funds or with grant funds. The media center will review proposals, supply model numbers and cost estimates and write a letter of support.

Smart Classrooms

Dr. Daniel Niemeyer
(http://www.classrooms.com)

Smart Classrooms Concept: at the University of Colorado

A new generation of high technology classrooms is becoming a necessity on college campuses, classrooms where it is easy for faculty to show computer output to a room full of students. More and more faculty are creating text, charts and graphics on their own computers and they want to bring this material into the classroom.

Faculty want to show information and research data from office computers or data bases worldwide. They want to access data from the computing center, current stock market quotations from Dow Jones, a NASA photograph from the Internet, a blueprint from the planning office, a rare manuscript from the library or a Van Gogh from the campus slide collection and display it all on a large screen for student viewing. They want to "take their office to the classroom."

Consultation with faculty interested in using computers for group instruction, visits to other universities, a survey of the literature and conversations with colleagues across the nation helped Academic Media Services at the University of Colorado frame a unique, flexible approach to meeting changing needs in the teaching environment. The objective is to make computer use in the classroom as simple, friendly and non-intimidating as possible. Installations must serve the faculty well, yet remain affordable.

Massive teaching bunkers full of intimidating computer hardware, invariably requiring the assistance of a technician, where faculty are expected to load necessary software and data files in the few precious minutes between classes, does not seem to be the most desirable model.

What is called for is a system that enables faculty, outside of class, to prepare text, charts, graphs, even complete desktop presentations and to practice the presentation as often as necessary. Users need to be confident that everything will work in the classroom without assistance and that, once in the classroom, setup time will take no more than a couple of minutes.

Begin designing technology classrooms with what is known. There seldom is adequate time to set up and wire together a display system between class periods, therefore the display system must be built in. Most faculty find it desirable to face students when using a computer in a classroom. A small computer screen is necessary so the presenter does not need to keep looking over his/her shoulder at the large screen. Faculty don't and shouldn't tolerate a massive desk/console barrier between them and their students. Faculty don't want to push a lot of buttons to make things work.

Since classrooms/lecture halls will continue to be used for traditional instruction, the front center of the room needs to accommodate chalkboards, overhead projectors, screens, as well as walking space for pacing professors, and open space for displays and experiments. Therefore any "lectern" for the computer needs to be small and placed at the right or left front of the room. This arrangement is similar to slide presentations, where the speaker is at a lectern on one side of the room and faces the audience while the visuals are shown on a screen in the center of the room.

Lighting control is critical. Adequate light is needed for student note taking. Sufficient light is needed at the computer "lectern" and on the chalkboard. All light fixtures must be located and controlled to minimize washing out the image on the screen.

In technology classrooms, there is a need for connectivity to outside teaching resources. Telephone lines, Ethernet connections or ISN installations make it possible to interact in real time with distant computers and workstations, databases, or banks of stored text and images.

The University of Colorado at Boulder offers a reliable and unique approach to the design of technology classrooms. Install video/data projectors in selected classrooms and provide a **user access panel** requiring little more than hooking **one cable** from the computer to a small lectern. A simple, user-friendly interface makes it possible to show campus cable TV, VHS videotapes, as well as computer displays from IBM and Mac machines, plus workstations. Creative, sophisticated engineering makes this possible. The key to success is careful selection of projector, user interface and VCR.

We looked for a video/data projector that could "automatically" determine which computer is connected to it, or if videotape or TV display is desired. Our projectors are programmed for most DOS/Windows machines, all Apple MAC computers, and for Sun and Silicon Graphics workstations.

Connecting the computer to the projector is accomplished with a 15-pin D-connector at a small lectern. AMS supplies a single, commonly available cable to connect the user-supplied computer to the video/data projector. A Lexan(TM) interface panel recessed into the wall contains the video/data projector controls and a VCR.

A major consideration is to please multiple users, many of whom do not plan on teaching with computers. We selected a VCR which plays VHS and S-VHS tapes. We use the VCR as a TV receiver, or as a tape player. To show a tape, one need only insert it into the machine, and play begins automatically.

Teaching in SMART CLASSROOMS began in 1993 with a pilot project to assess the viability of utilizing laptop computers for data sources. AMS lent Mac PowerBooks and IBM ThinkPads to a select group of faculty representing a wide spectrum of teaching disciplines. Based on feedback received, we suggest that **faculty bring a laptop computer**, already loaded with the necessary configurations, applications and files, **into the classroom**. We recommend that they place their portable computer on the room's small, simple lectern at which they may stand or sit.

As technological advances occur, smart classrooms at the University of Colorado will provide instantaneous Ethernet access to a wealth of still and moving images. It will be possible to get slides electronically from the Fine Arts Collection, manuscripts from Norlin Library, videos from the media center and historical photographs and films from the Library of Congress.

Unique Features of Smart Classrooms

Presentations require little set-up in the classroom
Faculty can work with their laptop computer to become familiar with the hardware and software outside of the classroom. Faculty are assured that their applications and files will be loaded on the computer in the classroom, since they load them on their laptop themselves before class

Laptop computers are simple, user-friendly, non-intimidating hardware
Faculty have a choice of platform (IBM, MAC, etc.). The portability of the laptop means faculty can get the computer set up and ready at their leisure and the presenter has more confidence that everything will be OK.

Connecting a computer in the Smart Classroom is simple
One cable connects the computer to the projector. Displaying computer output is as easy as playing a videocassette. Future changes cost less than upgrading complex teaching bunkers

The Smart Classroom is self-service. No technician is needed.
Since faculty operate the equipment without a technician, there is less staff cost.

There is no large bunker acting as a psychological barrier between teacher and students.

Ethernet connectivity provides access to information outside the classroom.
Files from an office computer can be loaded onto the laptop computer, or the office computer can be accessed in real time from the classroom using the laptop as a terminal. Internet text and images can be downloaded in the office and transferred to the laptop, or Internet text and images can be accessed in real time in the classroom using the laptop as a terminal.

Hardware for Smart Classrooms

Hardware in self-service Smart Classrooms
Faculty bring a laptop computer, already loaded with the necessary configurations, applications and files, into self-service SMART CLASSROOMS. Ceiling mounted Video/data projectors, requires just one cable connection from the laptop computer to a small lectern located in each room. A user access panel recessed into the front wall contains projector controls and a VCR. This simple interface makes it possible to show campus cable TV, VHS videotapes, as well as computer displays from IBM's and Mac's, plus workstations.

The hardware in self-service Smart Classrooms includes:

Large-screen video/data projectors
User access panel recessed into the wall and
Small Lectern with Ethernet connections

plus all equipment usually found in media-equipped classrooms:

Overhead Projector
VHS videotape player
35mm slide projector
16mm film projector

One call to the media center will get you:

Loan of a media closet key
Equipment operation instructions
Computer interface assistance and
Answers to questions

What Are Faculty Doing in Smart Classrooms?

Barbara Black, Assistant Director
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Faculty Use Laptop Computers in Smart Classrooms

Faculty began teaching in Smart Classrooms at the University of Colorado at Boulder in Fall 1993. Smart Classrooms are media-equipped, user-friendly environments with television; VCR; overhead, film and slide projectors, plus a video/data projector for showing output from Macs, IBMs and a variety of workstations. Faculty members bring their own computers, preferably lightweight laptops, to the Smart Classroom, loaded with the software and files of their choice. Ethernet connections in the rooms open the door to the information superhighway, making the vast resources of the INTERNET just a few keystrokes away. Smart Classrooms are the gateway to a world of information and engaging teaching.

A year-long pilot project began in Fall 1993 to answer a number of questions. How do faculty use computers for classroom presentations? Can laptop computers (Mac PowerBooks and IBM ThinkPads) "handle" varying teaching needs? Do improvements need to be made in the Smart Classroom design and user interface? What type of support do faculty teaching in Smart Classrooms expect and require?

Academic Media Services loaned laptops to eight faculty members to use as presentation tools. It was their responsibility to select and supply the software they planned to use and to obtain software assistance from the "customary" sources: manufacturer technical support, the University computing center, departmental colleagues and staff. Participants represented a cross-section of disciplines. Their computer savvy ranged from novice to hacker. Early in the project it became evident that they were hard-working, creative, problem solvers who were willing to experiment and take risks.

Some of the professors had a clear idea of how they wanted to use the computer; others saw value in exploring possibilities with students. Three used PowerPoint; one preferred Harvard Graphics; a number performed administrative tasks such as recording, calculating and analyzing grades. In the Smart Classroom, they demonstrated and solved problems with the same software that students use to complete course assignments; they employed a variety of calculating, graphing and data analysis programs to show how different values produce a variety of results; and they ran a variety of subject-matter-related software to illustrate course concepts. Initially most had no intention of using the Ethernet in the Smart Classroom, but by the end of the project at least half had incorporated it into one or more class sessions.

The Value of Smart Classroom Teaching
Professors were enthusiastic about how powerful an addition the computer was to their teaching. Testimony to this were statements such as, "There is no doubt that the quality of the presented course material was greatly enhanced when the computer applications were used." Or, "Higher quality PowerPoint presentations seemed to maintain student interest and motivation to understand concepts presented in class." And "The computer allows a wonderful degree of last-minute tailoring of material." Another reported that the computer "provided opportunities for outstanding diversity in course preparation."

Computers made it possible to do things in class which could not be done effectively any other way. Being able to show how to solve problems just like those students were required to do outside of class was a real asset for professors teaching engineering, kinesiology and computer science. Remarked one, "The tremendous advantage of using the computer was the ability to present procedures interactively, from the viewpoint that the students would have when working on their assignments."

Students were able to learn statistics in the context of the application program that they were using for their coursework. Live demonstrations reduced the amount of confusion that students often express in using a new program. Having the ability to walk through homework assignments and show students the correct answers and variations on the analyses was considered a real plus. Students could see the answers. The degree and type of interactivity possible with the computer was viewed as a major asset. Professors noted how attentive students were during computer demonstrations that often sparked significant and novel discussion.

For one faculty member the laptop and Smart Classroom offered personal satisfaction. "The PowerBook renewed my creativity for a course that I had taught for years," he confided. The Smart Classroom experience inspired another to write a proposal to equip his departmental computer laboratory with a projection system similar to that in Smart Classrooms. The proposal was funded!

Faculty Insights
Those electing to teach with computers begin with pre-set agendas, assumptions and expectations of what the computer will do for them and their students. Often what occurs is unanticipated and eye-opening. The most computer literate seem to face the fewest surprises, but may present the media center with unanticipated technical challenges. The less-experienced come face to face with a number of revelations which the more seasoned computer user accepts as verities.

It is difficult to manage more than one computer. Constant transferring of data from one computer to another can be annoying. Two professors in the pilot group saw a great deal of value in using the laptop exclusively. To give them the computing power needed, they suggested purchasing machines capable of docking. Some felt that it was essential to have a built-in modem for dialing in to

University computers from off-campus. For them, access to e-mail, the INTERNET, and a variety of campus servers was very important.

Developing computer presentations takes time. Nevertheless, it was agreed that the hours spent had their rewards. Statements from three of the participants bear this out. "Time spent on creating presentations helped to organize and clarify the delivery of information." And, "It took considerable preparation work to create presentation materials with PowerPoint, but PowerPoint proved to be an exciting tool; it holds a great deal of promise for development of the course." Plus, "It took longer than I had expected to develop interactive examples of spreadsheet calculations."

It takes planning to integrate computers into instruction. Two of the participants intended to use the computer as a teaching device early in the fall semester but realized that they needed time to purchase and learn new software, to develop teaching examples or desktop presentations, or to convert existing materials from overhead transparencies, word processing documents and spreadsheets. They opted to postpone classroom use for a number of weeks to accomplish these tasks.

Another participant remarked, "I can see that using the PC on a regular basis in class requires that I slowly build up a series of examples." At the onset of the pilot, one of the faculty planned to use the computer to replace the many overheads that had been developed over a number of years. She found that she would have to be patient and not expect to develop a collection of "electronic overheads" all at once.

Keep it simple. PowerPoint users, in particular, discovered principles of designing display materials that media specialists, graphic artists and instructional designers take for granted. As the semester progressed, the faculty saw the value of simplicity, legibility, use of white space and careful color selection. A typical remark was, "I reduced the text to a bare minimum, something I have learned since I started using the ThinkPad. I broke information into many slides and revealed one line at a time. I learned to simplify and carefully focus what I gave the class to look at on the screen; the software has helped me focus more clearly on the major points I want to make in lecture."

Relax and roll with the punches. "Near trips over cords, system crashes, intermittent problems with the projector color all contributed - positively - to the ambiance of the class; the students were frequently reminded that I was human and just as prone to problems as they." He added with a smile, "Why do programs always seem to run perfectly before the lecture but not when you're standing in front of a room full of students?"

Observations and Conclusions

Not every teacher sees value in desktop presentations consisting of text, bullet charts, diagrams and pictures produced with programs like PowerPoint. There are those who adamantly avow that the strength of computers is in their interactive capacity to perform what-if calculations and produce resultant graphs. One's subject-matter discipline seems to influence how the function and value of computers in the classroom are viewed.

Faculty are divergent thinkers who always seem to come up with new ideas for using computers in the classroom. Often these present new technical or logistical challenges requiring media center attention.

Computers enrich teaching of most courses, whether they are lower-division, upper-division or graduate level. More Smart Classrooms of varying sizes are needed, especially ones accommodating small classes of 25-40 students.

Faculty need software and pedagogical help. A number of faculty, especially PowerPoint users, believe that the campus should offer assistance in learning to use packages. One felt that to be really successful some pedagogical support from a teaching/technology expert would be in order.

Computing power, platform allegiances and software needs vary from course to course, professor to professor and discipline to discipline, making it inadvisable to loan a generic computer to faculty for classroom teaching. In the final analysis, the user is the best judge of his or her needs; a central campus agency is not. With computer ownership comes the responsibility for maintenance, upgrades and software purchases. Departments should budget for technology, including hardware, software and upkeep.

Today the bring-your-own computer concept works well. However, Ethernet access to servers appears to be the wave of the future. Stand-alone computers, even those with CD-ROM drives, may not be capable of storing and processing megabyte-hungry applications and large sound, picture and motion video files. As digital multimedia becomes more available and popular, ways to bring it into the classroom need to be addressed. Audio/sound reinforcement requests already have media center engineers and technicians hard at work devising a user-friendly amplification system for Smart Classrooms.

As we hoped, faculty feedback and technical support requests supplied the media center staff with the information needed to fine tune and make additions to the Smart Classrooms, and to assist faculty. We learned a number of interesting things, most notably that computers are making positive changes in the way UCB faculty teach, and students are the major benefactors.

Implementations across the curriculum

Maps and Mapping. A wide range of software and computer techniques were used to illustrate concepts that are difficult to get across without the aid of the visualization capabilities of a computer. On Fridays the professor would summarize the week's lectures with related software packages. Mac's ColorGlobe illustrated the effect of scaling space and time. AfterDark's Globe screen saver showed distortion effectively when a flat image (the Mac screen) is projected onto a globe and then viewed as if it were rotating. GeoCart map projection package depicted the great variety of map projections and distortions inherent in each. AtlasPro showed a wealth of thematic mapping options, including simple line and point maps, dot-density maps and choropleth maps. MacGlobe illustrated the strengths -- and weaknesses -- of inexpensive mapping programs.

TripPlanner, running under the SoftAT DOS emulator, demonstrated the ability of some packages to determine the shortest highway route between points and provide detailed itineraries. Telnet and the Ethernet connection made it possible to explore the rich variety of thematic atlases at the University of Colorado and the University of California libraries.

Physical Anthropology Harvard Graphics was selected to prepare bullet-list lecture outlines for almost every class and to present graphical information and tabular data. Often graphs were displayed along side 35-mm slides as the class explored genetics and race. The laptop was used to show a simulation of genetic change through time. "Showing results as they are calculated, as the computer can do, is much more powerful than a static bar graph," remarked the professor. To demonstrate the power of e-mail, the professor communicated with a colleague at Stanford University to get answers to questions about ethical issues surrounding the Human Genome Diversity Project.

Chemical Engineering Thermodynamics. The professor demonstrated how to use the software REACT! for homework assignments. The program was used to demonstrate that the heat of reaction changes with temperature, and to illustrate the change of the heat of reaction due to different heat capacities between reactants and products. With Quattro Pro the professor developed examples to show how to do bubble point and dew point calculations by plotting pressure versus mole fractions and temperature versus mole fractions. He then displayed the results of calculations with the graphing function of Quattro Pro, which also was used to develop interactive examples of spreadsheet calculations of vapor-liquid equilibrium and excess Gibbs free energy.

Business Information Systems and the Computer "Eclectic" best describes this professor's use of the PowerBook in a course focusing on computer hardware and software as they relate to business information. He, as well as guest lecturers, demonstrated Internet resources, River Simulation System, Lotus Notes, MacInTax, MacroMind Director, LXR-TEST, Hypercard, and Microphone. The professor experimented with developing presentations using PowerPoint and Aldus Persuasion.

Introduction to Kinesiology The most thorough application of presentation software occurred in this course. The professor's original intent was to use MS Word and a graphics program to show text and pictures during lectures. This approach proved unsuccessful and clumsy, leading to the adoption of PowerPoint. As time went on, his presentations took on a very professional quality. At the beginning of lectures he displayed objectives and then proceeded with informative bullet charts, scanned diagrams, illustrations and full color pictures to teach anatomy, biomechanics, motor control and exercise physiology.

Human Ecology Harvard Graphics was used for title slides, bullet lists, and simple tables or graphs. More complicated graphics and photos were on 35 mm slides. During lectures, computer and slide images often were presented side-by-side on two projection screens to study natural selection, overpopulation and environmental deterioration.

Future Trends in Organizational Communication. This upper division course with a small enrollment of 16 was ideal for professor and student exploration of a variety of applications: PowerPoint, NoteTaker, OptionFinder, E-mail, and the Internet. OptionFinder is an active response system where students use a keypad to react to questions or survey items. Results of responses then can be graphed or calculated for all to see, providing a powerful tool for fostering class participation and interaction. In combination with PowerPoint or NoteTaker, its value is even greater.

Statistics and Research in Kinesiology Excel 4.0 was employed to demonstrate statistical analyses. Students used the same program to complete assignments. The professor confided that this package was "sufficient but far from optimal" and chosen for its availability to students at University computing sites. The professor developed PowerPoint "slides" to present graphs, charts and lecture outlines. The laptop also was used during recitation sessions in which computer operations were demonstrated, problem analysis occurred and questions were answered.

Cartography 2/Computer Mapping. It is best to illustrate difficult mapping concepts or tools with the computer rather than to just talk about it as the textbook does. Course assignments included exercises with a variety of software packages (i.e., CorelDraw) on Mac and UNIX. The PowerBook was used as a terminal to access a UNIX machine in the geography department, making it possible to introduce the nature and use of software students would employ to create maps. The computer made it possible for the professor to recreate and resolve some of the problems or glitches students had encountered in laboratory situations.

Tips for Better Classrooms

Dr. Daniel Niemeyer
(http://www.classrooms.com)

TIPS for Traditional College Classrooms:

Large Writing Surfaces Are Essential. Surveys show that students prefer oversized tablet arms (130 sq. in) that provide room for note taking, calculators, and exam materials. A small (5' x 2') teacher's table provides adequate work space at front of room

Chair Rails Around The Perimeter of Classrooms Prevent Gouges in Walls. Chair rail should be 8" wide and mounted 25" above the floor to catch back of the chair and edge of the tablet arm. Fabric below absorbs sound

Reduce Ambient Sound Rather Than Try to Overcome Noise With Microphones. Quiet ventilation, electronic fluorescent light ballasts, and generous use of sound absorbing materials minimize needs for voice amplification

You Can Never Have Too Much Front Chalkboard. All available space in the front of the room should be chalkboard, 36" above floor, with tack strip. Black chalkboards provide the most contrast

70% of Faculty Prefer "Traditional" Chalkboards over White Boards. The responsibility and expense of providing markers for white boards is a continuing problem. Faculty become frustrated when markers dry out

Install Announcement Holders on the Wall Just Outside Each Classroom Door. To eliminate the marks from notices taped to walls, provide a display bar for faculty to post grades, notes, room changes etc.

TIPS for Large Classrooms & Lecture Halls

Mount Screens High Enough So All Students Can See Bottom of the Picture. Mount six foot screen 8.5' above floor; seven foot screen 9.25' above floor; eight foot screen 10' above floor, nine foot screen 11' above floor; etc.

Projection Booths Need Not Be Isolated. With less need to contain sound from film and slide projectors, open tables in the rear of the room meet today's requirements

Arrange Tiered Seats in a Semicircle. Tiered seating eliminates the need for a platform that inhibits faculty movement & requires a ramp to meet ADA requirements

Allow Adequate Space in the Front of Each Classroom for Overhead Projection. A 30 foot deep room with 40 seats needs 10 feet in front; a 35 foot deep room with 70 seats needs 11 feet in front; a 40 foot deep room with 125 seats needs 12 feet in front; etc.

Engrave Labels for Light Switches. Faculty need to know which switch controls what lights

Use Oversized Chalk in Lecture Halls. Railroad chalk or triple-thick chalk is easier to read from back

TIPS to Support Media-Equipped Classrooms

Switch Lights Parallel to Front of Room. Parallel switching provides some control for light just in the front, the center, or just in the rear of the room

Specify Screen Size for Each Classroom Based on Room Depth & Seating Capacity. A 30-foot deep room, with 40 seats, needs a 6-foot wide screen; a 35-foot deep room, with 70 seats, needs a 7-foot wide screen; a 40-foot deep room, with 125 seats, needs 8-foot screen; etc.

Several Small Screens Provide More Flexibility than One Large Screen. Presenters often want to use a chalkboard and projected materials at the same time; too large a screen obstructs the chalkboard

Locate a Media Cabinet in Front Corner. A stand for TV plus storage for a VCR and other AV hardware

Mount Television Sets 52" above the Floor. Creates a comfortable viewing angle; student sight line to TV screen will be the same as the sight line to the teacher's head

Add a Fold-down Table in the Rear of the Classroom for Film or Slide Projectors. A 30" deep, 28" wide table holds two slide projectors for comparing and contrasting images. Mount table 50" above floor when raised; near power

TIPS to Develop Smart College Classrooms

Recess Video/data Projector Controls & Vcr in the Wall in the Front Corner. Faculty need all of the controls at eye level in the classroom

Locate a Small Lectern in the Front Corner for a Laptop Computer. Include AC power, data jack and display connections at lectern. A larger bunker creates a psychological barrier between students and teacher

Ceiling Mount a Video/data Projector. Calculate 1.5 times the width of the screen to approximate the distance from the projector to the screen

Minimize Glare from Ceiling Lighting with Aluminum Parabolic Louvers. Adding 3" (78-cell), 1.5" (420-cell) and .5" (2,736-cell) parabolic louvers minimizes glare and light on projection screens

Control Chalkboard Lights to Maintain Readability Without Lighting the Screen. Controlled light is necessary for readability on the chalkboard when used with computer materials projected on the screen

Window Coverings Minimize Outside Light. Two coverings, recessed 2' blinds plus overlapping shades or drapes, give options for darkening the classroom

TIP for New Classroom Construction

Provide Plenty of Conduit for Future Use. Inexpensive 3/4" conduit should be run into each classroom for phone, fiber and co-ax; and 1 1/4" conduit should be run to the ceiling for display

Guidelines & Specifications

Dr. Daniel Niemeyer
(http://www.classrooms.com)

Guidelines are necessary to communicate media requirements to administrators, architects, and contractors, but each classroom requires individual interpretation and exceptions. The emphasis is on easy to use hardware, user-friendly controls and clear signage. This document is organized by topic (screens, media, lighting, seating, etc.) including special notes for lecture halls with seating capacity greater than 175 students. Many of these concepts are reflected in publications from MIT, the University of California at Davis and the Design of General Purpose Classrooms, Lecture Halls, and Seminar Rooms, edited by Sue Clabaugh, University of Maryland.

Screens

In the majority of classrooms, a matte projection screen mounted above the chalkboard in the center of the front of the classroom will fill video, film, slide & overhead projection needs.

Fit the screen to the size of the audience and the distance from the furthest seat. (See chart below)

Mount screen high enough for the students in the back of the classroom to see the bottom of the screen. (See chart below)

Multiple screens, for simultaneous projection in a classroom, provide more flexibility than one screen. Faculty projecting materials and wanting to use the chalkboard at the same time feel a large screen obstructs the chalkboard.

Overhead transparencies are projected from a table at least 10 feet in front of the screen, while films and slides are projected from a fold-down table in the rear of the room.

Attach Velcro to bottom of the screen cord and top of the chalkboard to prevent screen cord from hanging down the middle of the chalkboard.

Large lecture halls with capacity exceeding 200 students are equipped with a 10, 12 or 14' motorized screen. Lecture halls need two or more screens for projection of more than one image at a time.

Determining Screen Size & Mounting Height

The depth of the room and the seating capacity combine to determine the size of the screen installed in each room. Approximate figures are for an average square room.

<u>Classrooms less than 30 Feet Deep</u>**.** Measuring less than 35 feet from center of screen to rear corner seat. Seating 20 to 50 students in a classroom containing less than 900 square feet. Need a 6 foot screen, 72" wide by 72" high, mounted 8.5 feet above the floor.

Classrooms Between 30 Feet and 35 Feet Deep. Measuring between 35 feet and 42 from center of screen to rear corner seat. Seating 50 to 100 students in a classroom containing between 900 and 1200 square feet. Need a 7 foot screen, 84" wide by 72" high, mounted 9.25 feet above the floor.

Classrooms Between 35 Feet and 40 Feet Deep. Measuring between 40 feet and 46 from center of screen to rear corner seat. Seating 100 to 150 students in a classroom containing between 1200 and 1600 square feet. Need a 8 foot screen, 96" wide by 72" high, mounted 10 feet above the floor.

Classrooms Between 40 Feet and 46 Feet Deep. Measuring between 46 feet and 52 from center of screen to rear corner seat. Seating 150 to 210 students in a classroom containing between 1600 and 2100 square. Feet need a 9 foot screen, 108" wide by 78" high, mounted 10.75 feet above the floor.

Classrooms Between 46 Feet and 52 Feet Deep. Measuring between 52 feet and 58 from center of screen to rear corner seat. Seating 210 to 300 Students in a classroom between than 2100 and 2700 square feet. Need a 10 foot screen, 120" wide by 90" high, mounted 11.5 feet above the floor.

Classrooms Between 52 Feet and 58 Feet Deep. Measuring between 58 feet and 64 from center of screen to rear corner seat. Seating 300 to 400 students in a classroom containing between 2700 and 3300 square feet. Need a 12 foot screen, 144" wide by 108" high, mounted 13 feet above the floor.

Classrooms Between 58 Feet and 64 Feet Deep. Measuring between 64 feet and 70 from center of screen to rear corner seat. Seating 400 to 500 students in a classroom containing between 3300 and 4100 square feet. Need a 14 foot screen, 168" wide by 126" high, mounted 14.5 feet above the floor.

Additional Screen Considerations. For additional flexibility, add one or two screens on either side of the one center screen as sized above. Sometimes a classroom will lend itself to an additional corner screen at 45`deg. angle. Minimize overhead projector key-stoning with a cord & hook to pull the bottom of a screen back to wall.

Media Cabinet or Closet

A media cabinet fosters the comprehensive integration of media into the mainstream of the instruction, rather than permit the hardware to appear as a series of tangential afterthoughts. The media cabinet needs to be 52" high, 28" wide and 20" deep. It provides the stand for a 27" television receiver on the top.

Place media-cabinet /TV receiver in the front corner of a classroom so that chalkboards are not obscured. If the room has windows, the cabinet/TV should be in the corner near the window, facing into the classroom (facing away from window glare).

The front of the cabinet is at an angle so that the TV screen faces the rear center of the room.

If ceiling lights glare on the TV screen, tilt the TV slightly toward the floor to minimize glare from ceiling lights. This makes the back of the TV slightly higher than the front.

A locked door opens to reveal an upper shelf for a VCR and a bottom shelf with an overhead projector permanently located inside. The lock is opened by a key secured from the media center.

Additional media hardware can be deposited in the media cabinet on request. An autoload film projector with a 2" lens; one or two 35mm carousel slide projector(s) with a 4" to 6" zoom lens and remote; an audio cassette player, a CD player: and/or an LCD panel for showing computer output can be delivered.

Each cabinet has an AC outlet inside to power the VCR and the television receiver on top.

Each cabinet has a sign specifying the basic information necessary to utilize the hardware, and a phone number to call for assistance or more information.

If the seating capacity of the room is 40-60, a second cabinet is installed at the opposite end of the chalkboard in the front of the room to hold another TV receiver.

A video projector is installed in each classroom where seating capacity is more than 60 students. Controls for the ceiling mounted projector are conveniently located in a media panel near the front corner of the room. This media panel also incorporates a recessed VCR.

In these larger classrooms, a media closet, instead of a media cabinet, in the front corner of the room provides a place to store an overhead projector mounted on a movable cart.

For large lecture halls a booth in the rear of the room is desirable both for media equipment storage and operation with least disruption to the class. Entrance should be in rear of room.
A media closet is necessary in the front corner of the room for storage of an overhead projector on a movable cart.

Fold-down Projection Table
Each classroom needs a fold-down projection table with AC power and slide remote jack at the rear center of the room. Hinges allow the tabletop to be raised or lowered. The fold-down table is capable of supporting 80 pounds and is mounted to the rear wall of the classroom.

When raised, the tabletop is 50" above the floor, a height that allows projected images to appear above the heads of those seated directly in front of the projector. If the table is higher than 50" it is extremely difficult for a teacher to lift a film projector onto it and to reach up to thread the projector. The tabletop is 28" wide so that two film projectors or two slide projectors may be used at one time. Faculty often request two slide projectors so that they can compare and contrast images in the classroom. The shelf is 30" deep to accommodate a film projector with a large take-up reel. On the left side, as one faces the projection table, should be unobstructed space for the projectionist to stand. For large lecture halls projection booths provide surfaces for film and slide projectors.

Classroom Media

The primary classroom support mission of a college media center is the delivery of media services, not the daily physical delivery of equipment. Most media personnel will agree that more damage is done to equipment in transit than in use. Three elements are necessary to deliver media services into the classroom: (a) Create a series of various size media-equipped classrooms geographically spread around the campus to meet routine faculty needs; (b) Provide classrooms in the media center for occasional media users; and (c) Set procedures to accommodate emergency faculty needs. (See section on "Service to Non-Media-Equipped Classrooms")

In 1992, University of California at Davis faculty noted their needs for various types of media to enhance teaching and learning. Slide projectors were required by 60% of the faculty; overhead projectors - 60%; videotape players and television sets - 40%; 16mm film projectors - 20%.

Slides

One slide projector is needed for each media-equipped classroom. Instructional slides continue to be used in college classrooms, and requests for multiple slide projectors are increasing. On average, faculty request a slide projector in only some of the media- equipped classrooms, but in others they want two projectors. Upon request from a faculty member, a slide projector(s) is placed in a media cabinet for the semester.

Slide projectors should be equipped with a 4" to 6" zoom lens. When projected from the fold-down table in the rear of the classroom the image will fill the screen that has been appropriately sized for the room. (See "Determining Screen Size" Chart)

In addition, a zoom lens can help accommodate horizontal and vertical slides.
For large lecture halls two slide projectors are needed for the booth in each large lecture hall. High intensity slide projectors or Brightness Booster modules are needed to provide bright images at great distances.

Necessary distance between screen and a 35mm slide projector with a 4"-6" zoom lens for the projected image to fill the screen using horizontal slides and zoomed-out for the largest image and measured from film to screen.

a slide projector 27 feet away will fill a 6 foot screen (72"wide by 54"high)
a slide projector 32.1 feet away will fill a 7 foot screen (84"wide by 63"high)
a slide projector 36.6 feet away will fill a 8 foot screen (96"wide by 72"high)
a slide projector 41 feet away will fill a 9 foot screen (108"wide by 81"high)
a slide projector 45.5 feet away will fill a 10 foot screen (120"wide by 90"high)
a slide projector 54.3 feet away will fill a 11 foot screen (144"wide by 108"high)

a slide projector 63.2 feet away will fill a 14 foot screen (168"wide by 126"high)

Overhead Transparencies or Vu-graphs
One overhead projector is needed for each media-equipped classroom. The only instructional audiovisual device designed specifically for education, is used so frequently that an overhead projector with a 14" lens is permanently housed inside a media cabinet in each room. Keys to the locked cabinet are checked-out to faculty upon request for the day or for the entire semester.

Faculty remove the unit from the cabinet and place it on a table at least 10 feet in front of the screen to project an image large enough for viewing by students seated in the rear of the room.

An AC power outlet is available in the front of each media-equipped classroom for the overhead projector.

For large lecture halls two overhead projectors are place in each large lecture hall. An electrical outlet in the floor in the lecture hall front presentation area provides power. High intensity projectors are needed in large lecture halls, especially for LCD projection. When in use, an overhead projector is placed on a 32" high surface on a fixed table or on a rolling cart.

Necessary distance between screen and an overhead projector with a 14" lens for the projected image to fill the screen using 9.5 by 7.5" transparency frame and measured from lens to screen.

an OH projector 8.6 feet away will fill a 6 foot screen (72"wide by 54"high)
an OH projector 10.3 feet away will fill a 7 foot screen (84"wide by 63"high)
an OH projector 11.8 feet away will fill a 8 foot screen (96"wide by 72"high)
an OH projector 13.3 feet away will fill a 9 foot screen (108"wide by 81"high)
an OH projector 14.8 feet away will fill a 10 foot screen (120"wide by 90"high)
an OH projector 17.7 feet away will fill a 11 foot screen (144"wide by 108"high)
an OH projector 20.6 feet away will fill a 14 foot screen (168"wide by 126"high)

Films
One film projector is needed for every three media-equipped classrooms. Instructional films continue to be used in college classrooms, but their use is decreasing. On average, faculty request a film projector in only about 1/3 of media-equipped classrooms. Upon request from a faculty member, an autoload film projector is placed in a media cabinet for the semester.

Film projectors should be equipped with a 2" lens. When projected from the fold-down table in the rear of the classroom the image will fill the screen that has been appropriately sized for the room. (See "Determining Screen Size" Chart)

For large lecture halls two film projectors are needed for the booth.

Necessary distance between screen and a 16mm film projector with a 2" lens for the projected image to fill the screen using 9.5 by 7.5" transparency frame measured from film to screen.

a film projector 31 feet away will fill a 6 foot screen (72"wide by 54"high)
a film projector 37.2 feet away will fill a 7 foot screen (84"wide by 63"high)
a film projector 42.2 feet away will fill a 8 foot screen (96"wide by 72"high)
a film projector 47.7 feet away will fill a 9 foot screen (108"wide by 81"high)
a film projector 53 feet away will fill a 10 foot screen (120"wide by 90"high)
a film projector 63.5 feet away will fill a 11 foot screen (144"wide by 108"high)
a film projector 74 feet away will fill a 14 foot screen (168"wide by 126"high)

Lenses

It is necessary to standardize the lenses of film, slide and overhead projectors so that any device can be delivered to any media-equipped classroom. Select a 2" lens for each autoload film projector, a 4" to 6" zoom lens for each slide projector and a 14" lens for each overhead projector. These lens sizes match the size of the screen required to accommodate the variation in the distance between the screen and the projection table in the rear of each room.

Cost Estimates

Small media-equipped classroom with capacity 20-40 students

One-time capital items:

Screens	$100
Overhead projector	$300
Television Receiver	$600
VCR(VHS)	$300
Slide projector with lens	$600
Cables, connectors, adapters	$100
Total	$2,000

One-time room renovation costs:

Media closet/fold down table	$900-$1,500
Cable TV,AC power & phone jack	$600-$1,000
Lighting	$2,000-$4,000
Window treatment	$1,000-$3,000
Total	$6,000-$13,000

Continuing costs:

Parts & supplies	$ 150
.05 Staff	$1,200
Total	$1,350

Cost estimate for a larger media-equipped classroom with capacity 50-150 students

One-time capital items:

3 Screens	$ 400
Overhead projector	$ 650
Video projector	$6,700
VCR(VHS)	$ 300
Slide projector with lens	$ 600
Cables, connectors, adapters etc	$ 350
Total	$9,000

One-time room renovation costs:

Media closet/fold down table	$600-$1,200
Video projector mount installation	$600-$1,300
VCR, Panel & remote installation	$700-$1,000
Cable TV, AC power & phone jack	$600-$1,000
Lighting	$2,000-$5,000
Window treatment	$1,000-$3,000
Total	$5,500-$12,500

Continuing costs:

Parts & supplies	$ 200
.10 Staff	$2,400
Total	$2,600

Cost estimate for a "smart" classroom capacity 40-150 students

One-time capital items:

3 Screens	$ 400
Overhead projector	$ 650
Video/data projector	$16,700
VCR(VHS)	$ 300
Slide projector with lens	$ 600
Cables, connectors, adapters	$ 350
Total	$19,000

One-time room renovation costs:

Lectern (installed)	$1,000-$2,000
Corner Panel (with rack)	$2,000-$3,000
Media closet/fold down table	$600-$1,200

Video projector mount installation	$600-$1,300
Cable TV, AC power & phone jack	$600-$1,000
Lighting	$2,000-$5,000
Window treatment	$1,000-$3,000
Ethernet	$200-$500
Total	$8,000-$17,000

Continuing costs:

Parts & supplies	$ 300
.15 Staff	$3,600
Total	$3,900

Classroom Resources

Links to national organizations

AAHE....American Association for Higher Education.... http://aahe.org/

AECT.....Association for Educational Communications and Technology.... http://www.aect.org/
The mission of the Association for Educational Communications and Technology is to provide leadership in educational communications and technology by linking professionals holding a common interest in the use of educational technology and its application to the learning process.

DEMM....Division of Educational Media Management..http://teams.lacoe.edu/demm/demm.html
This division of AECT shares information on common problems, provideds solutions and program description of education media management, and fosters programs that help carry out media managment responsibilities effectively.

Cause .....association for managing and using information resources in higher education http://cause-www.colorado.edu/ CAUSE's mission is to enable the transformational changes occuring in higher education through the effective management and use of information resources--technology, service and information.

CCUMC.....Consortium of College and University Media Centers

Educom.....Transforming Education Through Information Technology ...http://educom.edu/
Since 1964, Educom has served the leaders who manage information technology in higher education. Through direct services, and cooperative efforts, Educom offers leadership and assistance to its member institutions in order to address critical issues surrounding the role of information technology in higher education.

Instructional Technology Resources......http://interact.uoregon.edu/CATE/HomePage

SCUP........Society for College and University Planning
http://www-personal.umich.edu/~scup/index.html

Tradelines..... Western Cooperative for Educational Telecommunications...http://www.wiche.edu
A program of the Western Interstate Commission for Higher Education (WICHE). Its mission is to improve the efficiency, quality, and impact of educational telecommunications programms and systems.

Links to Media Center and Faculty Teaching Center Home Pages

Media Center: Academic Media Services, University of Colorado
http://stripe.colorado.edu/~ams/mediactr.html
Faculty Teaching Center: University of Colorado Instructional Technology Resource Center

http://stripe.colorado.edu/~itrc/itcenters.html

Dr. Daniel Niemeyer
Resume January, 1997

Name &Title

Dr. Daniel Niemeyer, Classroom Consultant, University of Colorado, Boulder.

Education

Ph.d. in Instructional Technology, University of Colorado, Boulder, 1984.

Experience & Qualifications

Director of Academic Media Services at the University of Colorado at Boulder, 1984-1996, with campus-wide media, classroom design, imaging and multi-media responsibilities.

Senior instructor faculty teaching rank in the School of Journalism, 1980-present.

President of the National ITFS (Instructional Television Fixed Service) Assoc., 1985-1995.

Facilitator with architects, project managers, planners, administrators, faculty and professional technology staff. Responsible for classroom renovation, and serves as consultant on all campus construction and renovation. Translates technology needs into functional classroom designs. Recognized nationally for integrating technology into classroom design.

Professional Presentations

"Changing College Classrooms across the United States" presented at AECT national convention in 1996; "Smarter College Classrooms by Design" presented at SCUP national convention in 1995; "Designing TV Studio Classrooms that Work" presented at AECT national convention in 1995; "Nine Forecasts for 1999" presented at CCUMC conference at Notre Dame in 1994; "Smart Classrooms" presented at AECT national convention in 1994.

Publications

"Smart Classrooms", IALL Journal, Winter 1995.
"Tips for Better College Classrooms", NW Technology Journal, Spring 1995.
"Smart Classrooms", Perspective, Spring 1994. "Deliver Media Services...Not Hardware", TechTrends, 1989.
"Equipping A Classroom for Media", TechTrends, 1988.

Contributions to The College Classroom Environment

Pioneered media-equipped classrooms on the Boulder campus that now boasts 72 technology classrooms. With the adoption of media-equipped classrooms in 1986, physical delivery of equipment has been phased out completely. Developed smart classrooms in 1992. Sixteen newest classrooms on campus feature the laptop computer and video/data projector approach to computer presentation.

Sample of Consultations on Classroom Design And Presentation Technology:

American University, Washington, DC
Baylor University, Waco, Texas
Brown University, Providence, Rhode Island
California State Polytechnic University, Pomona, California
California State University, Northridge, California
Clemson University, Clemson, South Carolina
Colgate University, Hamilton, New York
Columbia University, New York City
Cornell University, Ithaca, New York
Dartmouth College, Hanover, New Hampshire
Harvard University, Cambridge, Massachusetts
James Madison University, Harrisonburg, Virginia
Lehigh University, Bethlehem, Pennsylvania
Mary Baldwin College, Staunton, Virginia
Massachusetts Institute of Technology, Boston, Massachustess
Monroe Community College, Rochester, New York
Princeton University, Princeton, New Jersey
Rochester Institute of Technology, Rochester, New York
Rutgers University, New Brunswick, New Jersey
San Jose State University, San Jose, California
Santa Clara University, Santa Clara, California
Southern Methodist University, Dallas, Texas
Southern Utah University, Cedar City, Utah
Syracuse University, Syracuse, New York
Towson State University, Baltimore, Maryland
Union College, Schenectady, New York
University of Alaska, Fairbanks, Alaska
University of California, Riverside, California
University of Chicago, Chicago, Illinois
University of Illinois, Champaign/Urbana, Illinois
University of Kansas, Lawrence, Kansas
University of Mississippi, Oxford, Mississippi
University of Missouri, Columbia, Missouri
University of North Carolina, Chapel Hill, North Carolina
University of San Diego, San Diego, California
University of Texas, San Antonio, Texas
University of Washington, Seattle, Washington

Vassar College, Poughkeepsie, New York
Virginia State University, Petersburg, Virginia
Williams College, Williamstown, Massachusetts

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